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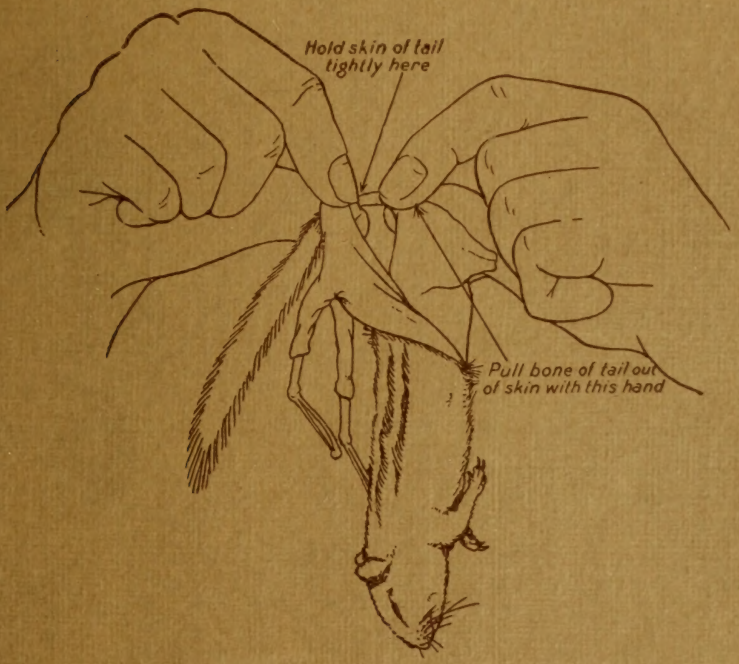
The Capture and Preservation of Small Mammals for Study



By H. E. ANTHONY

GUIDE LEAFLET No. 61

NOTE

These leaflets are intended to furnish accurate information in regard to the preparation of specimens of various kinds for Museum purposes.

The following have been issued and may be purchased at the sales booth or from the Librarian; others are in the course of preparation;

The Capture and Preservation of Small Mammals for Study
By H. E. Anthony. Price 15 cents

The Preparation of Birds for Study
By James P. Chapin. Price 15 cents

How to Collect and Preserve Insects
By Frank E. Lutz. Price 10 cents

The Preparation of Rough Skeletons
By Frederic A. Lucas. Price 10 cents

Suggestions to Collectors of Reptiles and Amphibians
May be had on application to the Curator, Department of Herpetology

Brief Directions for Preparing Skins of Large Mammals
May be had on application to the Curator of Mammals

THE CAPTURE AND PRESERVATION
OF
SMALL MAMMALS FOR STUDY

By H. E. ANTHONY
Curator of Mammals of the World

Third Edition

The American Museum of Natural History
Guide Leaflet No. 61
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THE CAPTURE AND PRESERVATION OF SMALL MAMMALS FOR STUDY

By H. E. Anthony

The small mammals of any region with certain exceptions are apt, to be less known than the large mammals. Small species which are active in the daytime, such as squirrels, are quickly noted and become familiar, but by far the greater number of small mammals are nocturnal in habit and hence escape observation unless special methods are adopted for their capture. The sportsman and large-game hunter acquaints himself in a short time with the appearance and habits of the large mammals of a region. He may spend years in a place without knowing by sight more than ten per cent. of its smaller mammal fauna.

As a consequence of this ability of the small mammals to escape notice, there is far less known about them than about the large, more or less spectacular mammals which the sportsman hunts for the pure love of the chase. Many of these game mammals range over extensive territory without becoming differentiated in any way or at the most differing only as subspecies. There is very little chance today for a hunter to shoot a species of large game new to science. On the other hand, there are very excellent opportunities for him to collect small species which have never before been taken, if only he will divert some of his attention to the mammals which he has been in the habit of considering beneath his notice. The shooting of a bear or lion is an achievement attained by thousands and often only a question of a moderate expense of time and money. These creatures were known to the ancients and the very nature of these animals demands that attention be paid them. There is no thrill of the chase, in the sense that one is risking his life, in the capture of some obscure, timid, and secretive small mammal, but if the species

is one that has never been known to Natural Science before, the discoverer should feel a satisfaction beyond that which attaches to ordinary trophies. It is distinctly worth while for the sportsman to spend some of his time and efforts upon the smaller mammals of the region he visits; especially is this true if he is hunting in some out-of-the-way corner of the globe, for the study skins he may bring back might be of far more value to Natural Science than the large animals which have always been filling the eyes of the sportsmen.

This is not intended as a dissertation against the scientific value of the large mammals,—far from it. Many of the large species are rapidly becoming extinct and if life-histories and intimate knowledge of these last survivors are to be obtained, surely no time must be lost. It is true, however, that a strong plea for the collecting of study skins exists, and men who go to great expense to reach new hunting fields could do a great service to museums, and to the knowledge of Natural Science, if they brought back with them as many of the small mammals as they could conveniently secure without interference with their plans for large game. Natives are often able to attend to the routine preparation of the material, or can be taught to do so, and the operation of a trap-line will not disturb the large mammals in any way.

This handbook has been written in response to a definite demand coming from two separate sources. Many of the sportsmen who plan trips to remote regions have made inquiry at this Museum as to what they might collect which would be of value for museum purposes. Their willingness to assist the aims of the Museum extends not only to the securing of the larger species for the exhibition halls, but also to a desire to be on the lookout for any mammals which have an especial interest or some particular bearing on any problem before the Museum. It may happen that the region under contemplation is the home of some much-desired small mammal and the offer of coöperation is decidedly welcome.

It is necessary then to instruct the sportsman in the methods of capture and preparation of small mammals.

The other class of naturalists for whom these pages are written is the individual who feels a definite calling to take up the study of wild life and who wants to know how to go about it. He may know something about removing the skin of a small mammal but he knows nothing about what constitutes museum methods and practice.

What is a Study Skin?

A well-equipped museum has, in addition to the mounted specimens of mammals on public exhibition, large series of specimens made up into what are called study skins. These series are necessary in order that the species may be studied to best advantage; that we may know whether the color of the animal varies with season, sex, or age, whether two mammals of similar external appearance really are the same in internal structure, etc., etc. It would be out of the question to attempt to care for the large collections brought together for this purpose by mounting them and placing the animals in the glass cases of the public halls. Study skins must be kept in storage cases that are light-tight, to prevent fading of color, and insect-proof; and the skins must be so prepared that many can be placed in one storage case. The method of making study skins strives to accomplish these two ends, — the preservation of all of the characters possessed by the animal when alive, and the production of a specimen which will be easy to store, protect and study. There is nothing in the preparation of a study skin which prevents the later mounting of the specimen for exhibition.

Tools Needed

Study skins of small mammals may be prepared with a small pocket-knife as the only tool, but skins may be made better and with less time if a few simple tools are secured

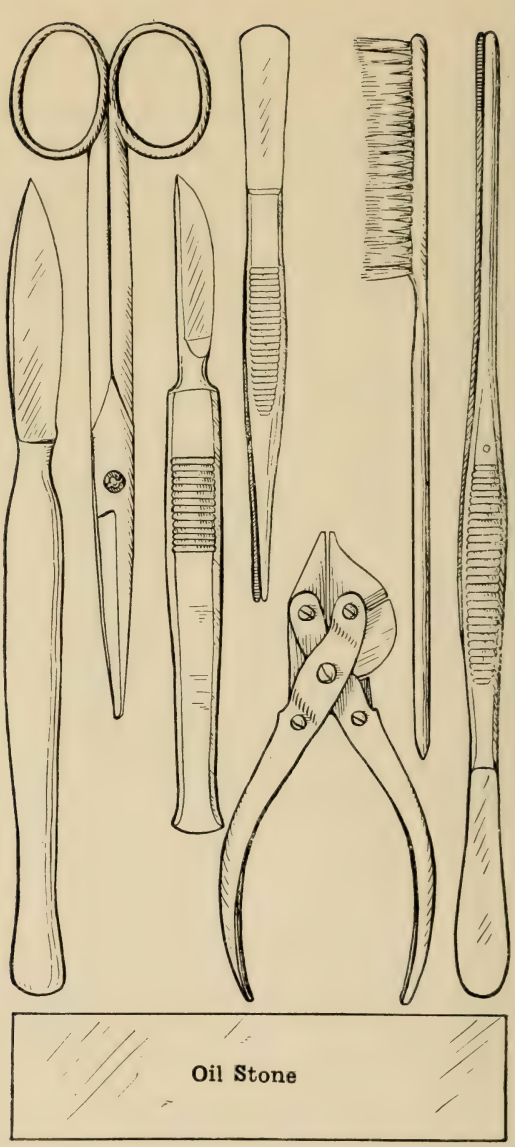


Fig. 1. Most important tools for making skins of small mammals.

The following will answer practically every purpose, but collectors develop individual methods and in time one might add several implements to this list.

1 steel tape, one or two meters long, marked in millimeters
1 steel ruler, about a foot long, marked in millimeters
1 small scalpel
1 large scalpel
1 pair of small, straight scissors
1 small pair of forceps or tweezers
1 large pair of forceps
1 tooth-brush
1 pair of pliers, with wire cutter
1 small carborundum oil stone

Additional tools that will probably be useful include extra scalpels, a larger skinning knife, a flat file, a steel comb, a larger pair of scissors, etc.

SUPPLIES NEEDED

Preservative

The skins of small mammals are best preserved by a mixture of arsenic and powdered alum (ammonium), the proportion about half and half by volume. Arsenic may be used without the alum but in a warm climate it is safer to employ alum to set the hair while the skin is drying. Do not use salt on a skin that is to be closed up, such as a chipmunk that is sewed up as a study skin. Sometimes when a collector runs out of arsenic he may make up his specimens without any preservative, and the skins will dry satisfactorily. They must be poisoned with the arsenic at the first opportunity, however, lest they be attacked by beetles (*Dermestes*) or moths, which may eat off all the hair.

A pound of arsenic mixed with an equal volume of alum will poison and preserve a great many small mammal skins, and ten pounds of the mixture will serve for quite an extensive expedition and for hundreds of small specimens.

The arsenic-alum mixture can be kept either in a flat, wide-mouthed tin (friction-top) or in a paraffin bag, made double by putting one bag into another.

Some collectors use powdered borax which will preserve the skin but does not guard against moths and beetles. If mixed with arsenic, borax may be used instead of alum.

Cotton and Tow

Cotton is employed as filling for small skins and may be secured in several grades. Tow, however, is the principal substance used for stuffing study skins, and if a fine, soft grade of tow can be purchased, the collector will seldom use his cotton. The tow should have long, soft fibers, and be free from lumps and dirt.

The very smallest skins need cotton, shrews, for example, being rather too tiny to fill with tow. For this purpose a fine

grade of cotton, Dennison's best cotton, or jeweller's cotton, should be selected. One half-pound roll of this will last a long time for the average collecting.

The cheaper cotton is useful to pack around dried skins, since it comes in a rolled-up sheet that may be opened out to lie smooth and flat.

Five pounds of the ordinary cotton and five or ten pounds of tow will be all that is needed for several hundred small skins.

Absorbent

The best absorbent to use in skinning and cleaning skins is fine, dry cornmeal or fine sawdust. Used freely, cornmeal is such an aid to skinning that plenty of it should be kept on hand. It can be used over and over again, simply throwing away each time only the bloody portions, and is best kept in a waterproof bag, the mouth of which can be rolled down and kept open when in use.

Three to five pounds of cornmeal will last as long as the cotton and tow listed above.

Needles and Thread

A paper of assorted needles to take No. 25 and No. 50 or 60 linen thread will be needed.

A spool of each of the sizes of thread listed, preferably white, will be ample for sewing up the skins of several hundred mammals, but if thread is used for other purposes, such as on labels or wrapping up skeletons, more spools of the coarser size will be needed.

Pins

Ordinary white pins may be used for pinning out skins to dry, but experience will soon demonstrate that the black steel pins with the round glass heads are very much more satisfactory. The larger heads of the steel pins save the skin of the fingers, and the hard points stick into the drying board

better. At least five hundred steel pins will be needed for active collecting, and a paper of the white pins will be useful for pinning paper about the dried specimens.

Labels

The American Museum of Natural History furnishes labels of standard pattern to its collectors. Such a label is shown in Figure 17. Lacking such a label, ordinary stringed tags such as Dennison makes may be used. Labels should be tied on firmly and a makeshift label that may be lost should not be used.

Wire

Wire in various sizes is needed for the tails of small mammals. A non-corrodible wire is much to be preferred and the American Museum has been using monel-metal wire with good success. Wire of monel-metal is made in several degrees of hardness. The most useful grade is the one with sufficient stiffness to keep the wire straight but not so hard that the wire will be spring-like. The sizes needed are Nos. 16, 18, 20, 22, 24 and 26. Mammals needing wire heavier than No. 16 are seldom made up in the field. Only the smallest of mammals require a wire as small as No. 26. By far the greatest number of skins will be prepared with Nos. 18, 20 and 22.

The weights of wire needed will vary with the region where collecting is done. If many large squirrels, rabbits, etc., are wired, the larger sizes will be required and five pounds of wire will not last long. On the other hand, a pound of No. 22 wire will serve for a hundred or more of small mammals.

Insecticide

In addition to the use of arsenic on the flesh side of skins as a deterrant for insects, it may be necessary to put some insecticide in the box with the dried skins when they are shipped or to prevent ants from eating away the ears, toes and lips of skins that are drying. Various substances may be used for this purpose—Naphthalene being probably the best.

California Insect Powder, Persian Insect Powder and Paradichlorbenzene (trade name, Paracide) may be used with success. The Paradichlorbenzene is especially effective but slowly evaporates if left out in the open; it is non-inflammable and non-explosive.

Alcohol and Formaldehyde

Alcohol is very useful for preserving specimens entire or for such soft parts of the anatomy as may be desired. The alcohol should be at least 85%. Avoid hardening the specimens by using the alcohol too strong, but beware of a weak solution in a hot climate.

Formaldehyde as obtained in a commercial solution generally runs about 40%. This solution may be diluted considerably. Take one part of formaldehyde by volume to from 10 to 15 parts of water, depending on the nature of the specimen, the climate, etc. Since formaldehyde hardens and contracts tissue, it is advisable to use it in a solution as dilute as will preserve from decomposition, and this may be as weak as a one to twenty solution under favorable circumstances.

Make certain that specimens are thoroughly immersed when placed in liquid; especially make sure that the fur is wet through.

Ink

India ink or water-proof carbon ink (Higgins' is an excellent brand) should be used for entering data on labels and in catalogues. Since the labels are comparatively small in size for the data that sometimes must be written on them, it will be found that a fine steel pen is best, because with it the letters may be kept small and entries legible. If the collector can print his data rather than write it, the label will be neater, but this, of course, is a refinement which adds nothing to the characters of the specimen itself.

The data on skull labels may be written in with pencil if a paper or card label is used. The writing must be heavy enough to insure its permanence.

GENERAL INSTRUCTIONS FOR THE CAPTURE OF SMALL MAMMALS

Most small mammals will be secured by trapping: only a comparatively few will be shot.

Squirrels and rabbits will more often be shot than trapped. For shooting small mammals a double-barrelled shot-gun is best and a 16-gauge gun will answer all but the most unusual requirements. The right hand barrel should have a modified choke, the left should be full-choked. Auxiliary barrels, to be fitted inside of the 16-gauge bore, are very useful devices and do not add greatly to one's equipment. The auxiliary barrels now used by the American Museum are .32 caliber, using the old .32 extra long center-fire shell (to be obtained only on special order from the factory) and .410 caliber, using a paper shell which can be obtained without difficulty ready-loaded. The length of the auxiliary barrels is about five to eight inches and the barrels may be carried in the pocket when not used in the gun.

For the 16-gauge shells, No. 6 shot is the best all-around size, but there will be use for No. 8 and No. 10 shot, as well as for No. 12—if bats are to be collected. Larger sizes of shot up to BB and buckshot will be required, of course, for general collecting. The small shells for the auxiliary barrels are most often loaded with No. 12 shot.

It would be impossible to give, in this handbook, complete instructions for the successful hunting of small mammals in each part of the country. Local conditions require special methods and it is presumed that any one who is seriously using this manual has probably already had at least the average hunter's experience and will know how to hunt for squirrels, rabbits and such small game. Space may be taken here for a few hints, however.

The best times for hunting are early in the morning, just after sunrise, and late in the afternoon until it is too dark to

shoot. Look for the mammals where it is known that they feed. A tree of ripe fruit, a corn-field, a patch of clover, all offer a promise if visited at the right time. Some mammals may be called up by squeaking with the lips pressed against the back of the fingers.

Often mammals which could never be taken by ordinary methods of daylight hunting may be shot by hunting with a light at night. Night hunting or "jacking," as it is sometimes called, is against the law in most of the states of the Union, but this practice may be followed in other regions where it is the most efficient method for large as well as small species.

The best light for the purpose is an electric flashlight, so constructed that the reflector with the bulb may be pinned to the hat in front and the batteries carried in the pocket. A five-cell dry battery gives a very strong light and will last for many hours of continuous use. Used for two or three hours a night, a set of cells may last for several weeks. Carbide lights made especially for jacking are on the market but are so cumbersome and inefficient as compared with an electric light that they should be used only as a last resort if the flashlight cannot be obtained.

The light is so fastened on the hat that when the gun is thrown up to the shoulder the beam of light follows the line of sight. Mammals are seen at night by the reflection from their eyes and it is seldom that the hunter sees more of the game than the two glowing spots. The color of these spots varies with the species of mammal and may be bluish for deer, reddish for cats, etc. The color of the eyes and the distance between them serve as identifying characters. Care must be taken to avoid accidents. The eyes of cattle, horses, and other domestic stock shine beautifully under the light and it is much better to be cautious at first than sorry afterward. Night hunting will never make the collector popular with the natives if he shoots first and learns afterward. The eyes of man do not reflect light, at least under normal circumstances.

It is not unusual for a hunter to fire at a star when shooting at night. The wind moves the leaves of a branch aside and the star seems to move as would the eye of an animal. A good test under such circumstances is to watch the supposed eye when the light is on it and after the light has been turned to one side. If the "eye" remains visible when the light is removed it is a "star" but if the "star" shines only when the light is on the spot it is an "eye." The eyes of many creatures shine at night and it will require some experience before the hunter is able to identify what he sees. The eyes of spiders, moths, and insects often shine and sparkle amazingly; owls and night-birds, such as the goatsuckers, have luminous eyes that are very misleading; lizards may reflect light from the eye, and alligators and crocodiles send back the rays of light.

It is advisable when hunting at night, especially when in an unknown region, to reconnoiter first by daylight and learn the terrain and the features of the topography. This not only helps to bring the hunter back to camp the same night, but serves to prevent shooting-up a native's barnyard, and locates fruit trees where mammals are feeding, streams they may visit, etc.

Care of Mammals after Shooting

When a mammal is shot the specimen should be so cared for that no unnecessary bleeding takes place. Wounds may be plugged with cotton and the bleeding checked. A hunting coat with large pockets is suitable for carrying specimens the size of a squirrel, and smaller mammals should be brought to camp and skinned there. Larger specimens, the transportation of which is troublesome, may be measured and skinned out roughly where they are shot but the details of the skinning which require time, such as skinning out the hands and feet, may be left until later. If the temperature is high and the specimen may spoil before it can be given the time to skin it out, the removal of the viscera is advisable. In some cases it

may be advisable to wash the body cavity with a weak solution of formaldehyde,or even to inject a specimen with this solution.

Trapping Small Mammals

Trapping of small mammals is not difficult in most temperate regions, but in some places, notably in tropical America, it is an art not easily acquired. A trap-line should contain as many traps as the collector can give his attention after the various duties of a day are taken into consideration. In the tropics, where traps must be visited soon after sunrise and specimens must be skinned out the same day they are caught, the trap-line should be neither too long nor too far removed from camp. Where high temperatures do not exist much greater latitude may be taken.

To get a complete representation of the small mammals of a region, a collector should run a line of traps in every definite life-association area. That is to say, traps should be set along streams and ponds for the aquatic species, at the foot of trees, on logs or on boughs for the arboreal mammals, in high grass and bushes for the meadow-loving forms, and in burrows and holes for the digging or subterranean creatures. A good plan is to set out traps in such a fashion that by following an arc of a circle the collector will place some of his traps in each one of the special situations the region affords. A trap-line that leads directly away in a straight line may capture just as much as one that curves back again toward camp, but it is obvious that time will be saved in the latter instance when returning with the catch.

It is not easy to set out a large number of traps and then locate them the next morning without loss of time. By following prominent features of the topography this task is simplified. Traps can be set along a trail or a stream in likely places, or along the crest of a ridge. It is a help to place small markers on the twigs or vegetation near the trap and to adopt a system which tells something of the position of the traps.

A tuft of cotton twisted about a twig or blade of grass will catch the eye and call attention to the trap. If nesting birds remove the cotton, short lengths of white string may be used. Single markers may be used on each trap except for the third, when two markers are set out. A bit of colored calico could be used on the fifth trap. When running the line, therefore, the collector knows he must find three traps for

Fig. 2. Showing trap set close to log.

each double marker and five for each colored one. This often saves time and avoids running the line back very far to find the lost trap.

If natives are troublesome and steal traps too conspicuously marked, as they often do, another method must be employed. Twigs broken and hanging down, a blaze or knife-cut on a tree trunk, an overturned stone, and other similar expedients to catch the eye will serve to mark trap.

Quite often the most suitable places for traps are obvious to the collector. Under fallen logs, in holes under rocks or at the

bases of trees, in runways through the vegetation, or at any place where it is apparent that shelter or food exists, traps may be placed with confidence.

In some regions traps placed carelessly at random can not fail of a good catch; elsewhere, under conditions that appear much more favorable, a line of 100 carefully placed traps may yield only two or three mammals. When setting out traps it is advisable to place the trap so that animals may trip it in passing if they are not interested in sampling the bait. By taking advantage of natural lines of cover this can generally be done, and the figure on page 16 shows a trap placed against a log so that any rat or mouse running along in the shelter of the log must trip the treadle in passing.

When a runway is discovered the trap may be placed directly in it, preferably across the runway because there is less chance of the mammal being thrown clear by the spring. It may be necessary to remove some of the floor of the runway in order to bring the trap flush with the surface. Burrowing mammals may be difficult to catch because they fill the trap with earth. Pocket-gophers and moles are especially troublesome in this respect, but the collector learns by the failures and evolves a technique to avoid this. Traps of special types are made for gophers and for moles and are more effective than steel traps.

Some aquatic mammals seldom run on the land and are not easily caught in the water. By searching for places where these mammals must take to land, at a waterfall for example, traps may be placed in the paths they must follow and specimens are secured. Under normal circumstances, mammals may be counted on to do the obvious thing, and this should be taken into consideration in the placing of traps. If a mammal standing on the ground is unable to reach a bait, it is quite apt to climb up on the nearest object which allows it to reach the morsel. If a low obstacle is in its path, it steps over it, and a trap may be set where the foot

comes down. The trappers of furs have many such methods, and while most small mammals apparently are not suspicious of traps, there are occasions when the resourcefulness of the collector is taxed.

The small traps for rats and mice should always be tied down to prevent a captured animal from dragging the trap away. Steel traps always have a chain fastened to them for this purpose but it will be necessary to put a cord or a small wire on the wooden traps. About two feet of strong, hard cord can be tied into the staple which holds down the trigger.

The bait for the small traps should either be sprinkled sparingly over the treadle and in front of the trap in the case of a loose bait, such as rolled oats, or else be placed directly in the bait hole in the treadle if the combination bait is used.

Small steel traps are often set, unbaited, in a runway or burrow. If a bait is employed it may be dropped here and there about the trap and then a few leaves scattered on top or it may be suspended over the leaf-covered trap so that the animal steps into the trap while reaching for the bait.

Traps

The traps required for the capture of small mammals are of two main types. The traps for rats and mice may be of the common spring and board pattern, such as the Out-O-Sight; and the traps for the larger mammals are preferably a selection of different sizes of steel traps, the Newhouse and the so-called "jump" trap. These traps are standard and can be obtained almost anywhere.

The small traps on the market come in two sizes, a mouse size and a rat size. The American Museum has found it necessary to use a small trap intermediate in size between these, but such a trap must be made to order. It may be ordered from the Animal Trap Co. of America, Lititz, Pa.

Secure the best-made trap to be found; a cheap trap will warp and break after a hard rain. The Out-O-Sight trap has given the most satisfaction of any used by the American Museum. These traps with wooden bases may be placed in hot paraffine for a minute or two and then placed in a warm spot to drain, or linseed oil may be used with equally good results although the traps may need inspection later to remove any gummy deposits on the treadle. This makes them water-proof and adds nothing that is distasteful to the animals which will visit them.

For active trapping at least 100 of the mouse traps would be carried and 50 of the rat size. Since traps occasionally break or are lost, a greater number will be needed when col-

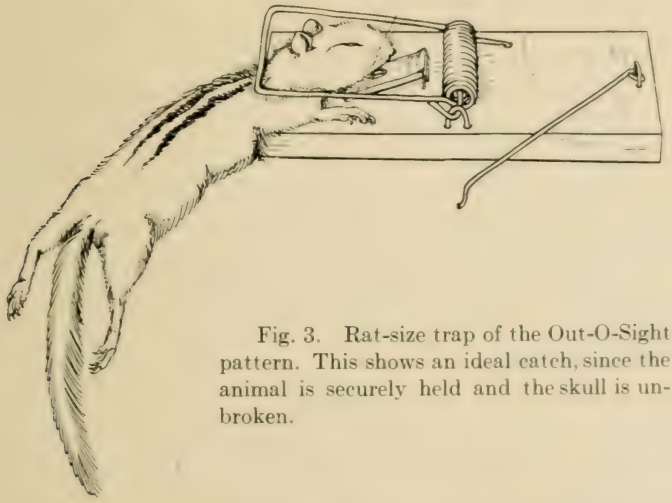


Fig. 3. Rat-size trap of the Out-O-Sight pattern. This shows an ideal catch, since the animal is securely held and the skull is unbroken.

lecting over a long period. An average trap-line will mean about 100 traps out a night, more if mammals are difficult to secure, less if they are abundant. In some regions the proportion of rat to mouse size should be increased, or vice versa.

Baits

There are many baits which may be used successfully in trapping small mammals. Rolled oats is a standard bait for rodents. Bits of bacon, dried fruit, peanut-butter, cut-up vegetables or fresh fruit also serve for rodents; and for the small carnivores, scraps of fresh meat, bird bodies or carcasses from the skinning table may be attractive.

The most generally successful bait used by the American Museum collectors is a mixture or combination bait which I have worked out on the basis of field work in Ecuador. It is made as follows:

> One part of bacon, cut up into small pieces; one part of cluster raisins, also cut up small; two parts of oily peanut-butter; rolled oats sufficient to make the mixture of putty-like consistency.

The bacon and raisins may be run through a food chopper if much of the bait is to be prepared. All of the ingredients should be thoroughly mixed and the final product will keep for months or years if stored in a tight jar or tin.

This combination bait is attractive not only to rodents but to shrews, opossums, and other small mammals. Unless carried away by ants, the bait lasts for several nights and is unaffected by light rains because of its oily nature.

No very signal success has been obtained by the use of special scents, such as asafœtida, fish-oil, etc., in trapping for smaller mammals.

Poisons

The use of poisons is not generally recommended for taking small mammals. Circumstances seldom justify the use of poison and because of the uncertainty of finding the mammal after it has left the bait, it is a wasteful process.

MEASURING AND LABELING OF SPECIMENS

Each specimen should have tied to it a label with the following data:

1. The number given to the specimen by the collector.
2. Locality or place of capture.
3. Date.
4. Sex.
5. Measurements.
6. Name of Collector.

1. A catalogue of the specimens collected should be kept from day to day and a number assigned to each animal as it is skinned. This number is written not only in the catalogue but on the label which is tied to the skin and on the label which is fastened to the skull.

2. The locality where a specimen has been taken may be shown in various ways. If the place is well known and to be found on the map, the designation may be by two or three words, as, for example, Hastings, New York. If, however, the locality is at a distance from any well-known spot on the map, a designation as above is hardly sufficient and an explanatory clause should be added, as, for example, Santa Rosa, Chillo Valley, east of Quito, Ecuador, altitude 8000 feet.

3. The date is best written out, May 7, 1925, not 5-7-1925, which might be construed either as the seventh day of the fifth month or the fifth day of the seventh month.

4. The sex is ordinarily determined by inspection of the external sex organs or genitalia and only rarely is it necessary to make an internal dissection to ascertain whether the specimen be male or female. The sex is best indicated on the label by sign, ♂ for male, ♀ for female.

4. The measurements are of considerable importance and should be taken in millimeters whenever possible. The measurements ordinarily taken are the total length, the

length of the tail vertebræ, and the length of the hind foot. European collectors and workers prefer to take the length of the head and body and the length of the tail, arriving at the total length, if they wish it later, by addition. The American method will give the length of head and body, if it is desired, by the process of subtraction.

The total length is the distance in a straight line from the tip of the nose to the tip of the tail, exclusive of the hair. The animal is straightened out so that there are no curves in

Fig. 4. Showing method of securing total length.

the vertebral column and, if *rigor mortis* has set in and the animal is stiff, the carcass must be stretched and manipulated to bring it into a natural position. Place the specimen on a board or table, as shown in the sketch, and set a pin at the tip of the nose and at the end of the last vertebra of the tail. It is possible to take the total length by holding a small mammal directly on a ruler, with the end of the ruler at the tip of the nose, and locating the tip of the vertebra with the thumb or fingernail, taking a reading from the ruler without recourse to pins. For one who is learning, the measurement will be more accurate if pins are used and the ruler applied to them.

The length of the tail vertebræ is taken as shown, from the base of the tail to the skin of the last vertebra. The tail is bent at right angles to the body to facilitate the taking of this measurement.

The length of the hind foot is taken from the heel to the end of the claw on the longest toe. The toes should be straightened out and the easiest way to keep the foot straight

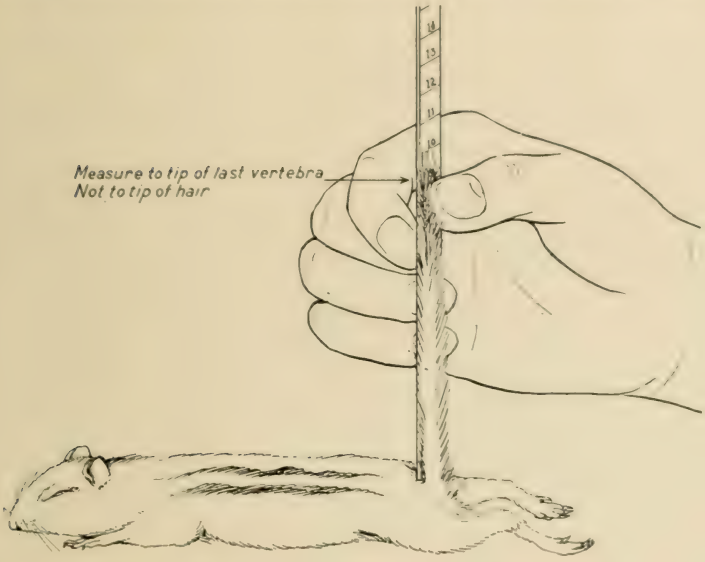


Fig. 5. Method of taking length of tail vertebrae.

is to press it against the flat side of the ruler, as in the figure. Some collectors prefer to take this measurement with a pair of dividers. This way of taking the hind foot measurement to include the claw, often written as "length of hind foot, *cum unguis*," or simply "length of hind foot, c.u.," differs from the method employed by Europeans who measure only to the fleshy tip of the longest toe. This measurement without the claw is known as "length of hind foot, *sine unguis*," or "length

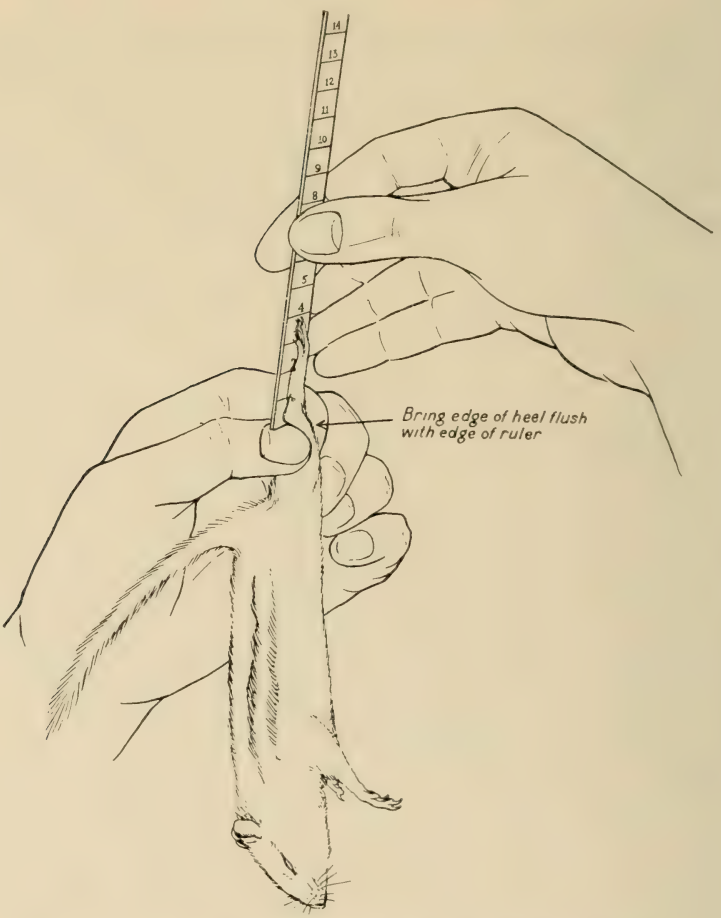


Fig. 6. Method of measuring the length of the hind foot.

of hind foot, s.u." Specimens collected for the American Museum of Natural History are always measured to include the claw in the length of the hind foot.

Sometimes the height of the ear above the crown of the head affords a valuable measurement. This is written on the

label, "height of ear above crown," and may be taken by placing the end of the ruler on the crown of the head at the base of the ear and then reading to the tip of the ear, exclusive of the hair.

The weights of many mammals are known from only a few records or perhaps are merely estimated. If one has the means of weighing the mammals taken, these figures should be recorded on the label.

Field Catalogue

It is important to keep a field catalogue of the mammals collected and to record in it all the data that is written on the label and such additional notes as seem worth while (see page 52). This catalogue may be any convenient size. The catalogues used by the American Museum give a line to a specimen, but the line runs across two pages and the data is entered in this order: collector's number, name of mammal (in the field this may be only "rat," "mouse," "squirrel," etc.), sex, locality, date, measurements, remarks. By writing remarks at the right-hand margin of the page there will be ample space, since extensive remarks will not be given for each specimen and if the part of a line regularly allotted to a particular specimen is not adequate, the note can be run over a line or two without crowding the page.

TO SKIN A SMALL MAMMAL

A chipmunk is selected as a typical small mammal, and mammals up to a raccoon in size are skinned in this fashion. The very first things to be done are the taking of measurements, the writing of the label, and the recording of data in the field catalogue.

With the chipmunk laid on its back, part the fur along the mid-line of the abdomen and make the opening cut from

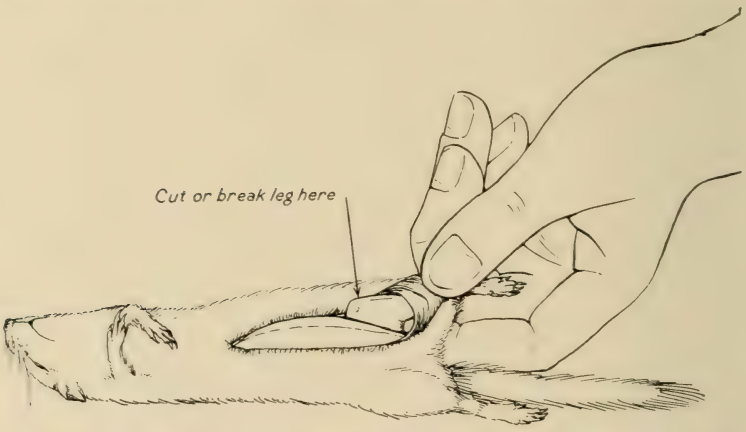


Fig. 7. Showing the opening cut and one leg freed from the skin at the knee

about the breast bone to the base of the tail. Figure 7 shows the extent of this cut, which should be through the skin only and not into the abdominal cavity.

Loosen the skin from the flesh along the sides of the cut, using the fingers or the flat end of the scalpel handle. A pinch of dry cornmeal dropped into the cut will be of considerable help in manipulating the skin.

Keep a container with cornmeal on the skinning table and do not be sparing in its use. Cornmeal not only absorbs the body juices, keeping the fur and skin clean, but the

Fig. 8. The leg has been disjointed at the knee and the flesh has been stript from the tibia.

Fig. 9. Removing the tail vertebrae.

presence of the sharp grains on the fleshy side of the skin is a great aid in working and handling an otherwise slippery surface.

Work the skin loose from the knee and upper leg so that the knee-joint may be thrust upward, as in Figure 7, disjoint the leg at the knee and work the skin back as far as it will go. Clean the flesh from the lower part of the leg. See Figure 8.

Skin out the other leg in the same manner.

Cut away with the knife or scissors any tissue at the base of the tail and work the skin of the tail loose until it may be grasped as in Figure 9. The skin may be grasped between thumb and forefinger with the fingernails serving to strip the skin from the bone. Forceps may also be used to do this stripping. A steady pull on the base of the tail should bring the vertebræ out entire. Occasionally a mammal is found, the tail of which must receive special treatment, or a shot may have cut a vertebra. In that event the skin of the tail may be split for a short distance along the under side and sewed up afterward.

With both legs and the tail free, the skin is rolled back until the forelegs are reached. This parting of the skin from the body may be accomplished partly by manipulation with cornmeal and the blunt handle of the scalpel, partly by cutting strands of tissue here and there.

The skin should never be pulled until it stretches, at any stage of the skinning.

The forelegs are worked free of the skin, disjointed at the elbow, and cleaned in much the same manner employed for the hind legs. See Figure 11.

The skin is then rolled back until the bases of the ears are reached. Cut these with the scalpel as close as possible to the skull; do not cut the bone of the skull, however. See Figure 10.

As the skin is worked over the head, the eyes will be exposed. Cut the eyelids free with the point of the scalpel,

working carefully to avoid cutting the lid This means that the point of the knife must work deep. Probably the novice will learn just how deep only by passing through the experi-

Fig. 10. Skinning about the ears.

ence of cutting off a few eyelids. The skin is cut free at the nose by slicing through the cartilage; take care not to cut the delicate bones of the nose.

The skin finally parts from the body at the lips and is now turned inside out, as shown in Figure 11. Clean off any bits of fat or meat on the skin. It is especially important that

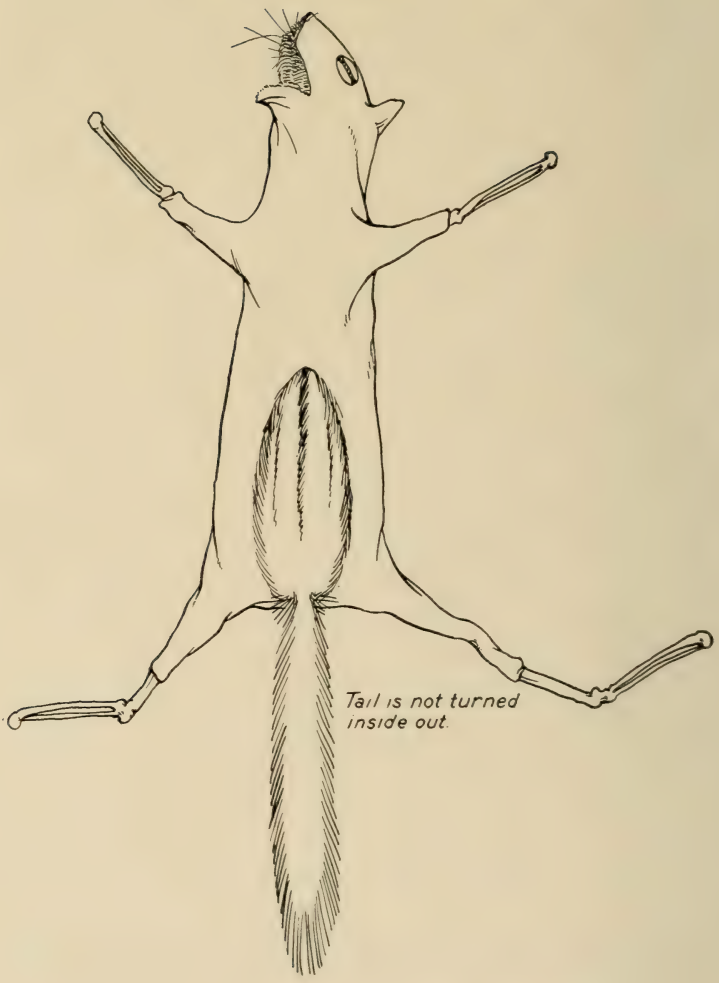


Fig. 11. The skin removed from the body.

all fat be removed from the skin. Take three stitches to close the lips. See Figure 12. Do not take these stitches too deep into the lips.

If the skin is especially greasy or bloody, it may now be washed thoroughly inside and out with soap and water or in benzine. Avoid stretching the skin while it is thus wet and lax, but otherwise it may be handled like a piece of cloth. Squeeze out the surplus moisture; do not wring out the skin lest it stretch; and dry the fur by a liberal use of dry cornmeal or sawdust. As fast as the cornmeal absorbs moisture and becomes damp, replace by fresh, dry cornmeal and very shortly the fur will be dry and fluffy. The skin may then be turned inside out again to be poisoned.

Fig. 12. Stitching the lips.

Now dust over the skin thoroughly with the arsenic and alum mixture, using a small brush, a rabbit's foot, or a tuft of cotton on a stick. See that the powder comes in contact with every part of the flesh surface. Work some of it into the tail, using a wire to dust it down past the base of the tail.

It should be needless to caution the worker that the arsenic mixture is poisonous if taken into the stomach. It is also a powerful irritant if it gets under the fingernails. The use of cornmeal in skinning generally protects the fingers, because the cornmeal gets under the nails first and prevents the accumulation of arsenic there. Do not dip the fingers into the arsenic if it can be avoided.

Shake off any excess arsenic and alum; turn the skin right side out.

If the mammal is of fairly good size, and the climate is

such that skins do not dry quickly, it will be advisable to slit the soles of the feet in order to get arsenic in at the base of the toes and about the phalanges. Perhaps it will be possible to remove some of the fleshy tissue from the soles of the feet through this opening, which can be made either at the extreme edge of the palm or sole, or down its median line. The opening may be closed by a stitch or two after the preservative has been sifted in.

TO FILL OUT THE SKIN OF A SMALL MAMMAL

Prepare a body of tow for the chipmunk, pulling out the fibers until all point the long way of the body. Do not make the body too large: judge the size somewhat by the size of the carcass you have just removed but remember that the tow will compress.

Bend over the tow at the extreme end of the body so that the short ends of the long fibers are directed back along the body and the head end of the tow form is bluntly rounded. Grasp this end with the forceps and insert the tow into the skin, working it into the head and nose, as shown in Figure 13. Fill out the nose and shape the head, drawing the skin of neck and body smoothly over the form. Cut off the tow so that the new body just fits at the base of the tail.

Twist up a wisp of tow over the points of the forceps by twirling the forceps in the tow, slip the tow into the leg between the bone and the skin as far as it will go, grasp the point with the fingers of the free hand and the forceps may be withdrawn, leaving the tow in the leg. The leg should be drawn out straight as this is being done. See Figure 14. One wisp of tow is sufficient for the foreleg but two will make a better hind leg.

The next step is to wire the tail. Straighten out a piece of wire by pulling on it until it gives a trifle. Cut off a length equal to the length of the tail plus the length of the opening cut in the skin. The size of the wire should be such that it will go to the end of the tail and still be stiff enough that it will not bend easily. In the case of species where the tail is long and tapers to a fine point, it may be necessary to dress down the terminal inch or two of wire with a file.

Twist a little cotton or tow tightly about the wire to fill out the tail. At first it may prove difficult to get a thin, even layer of cotton on the wire; the knack comes with practice and consists principally in adding the cotton, a thin wisp at a

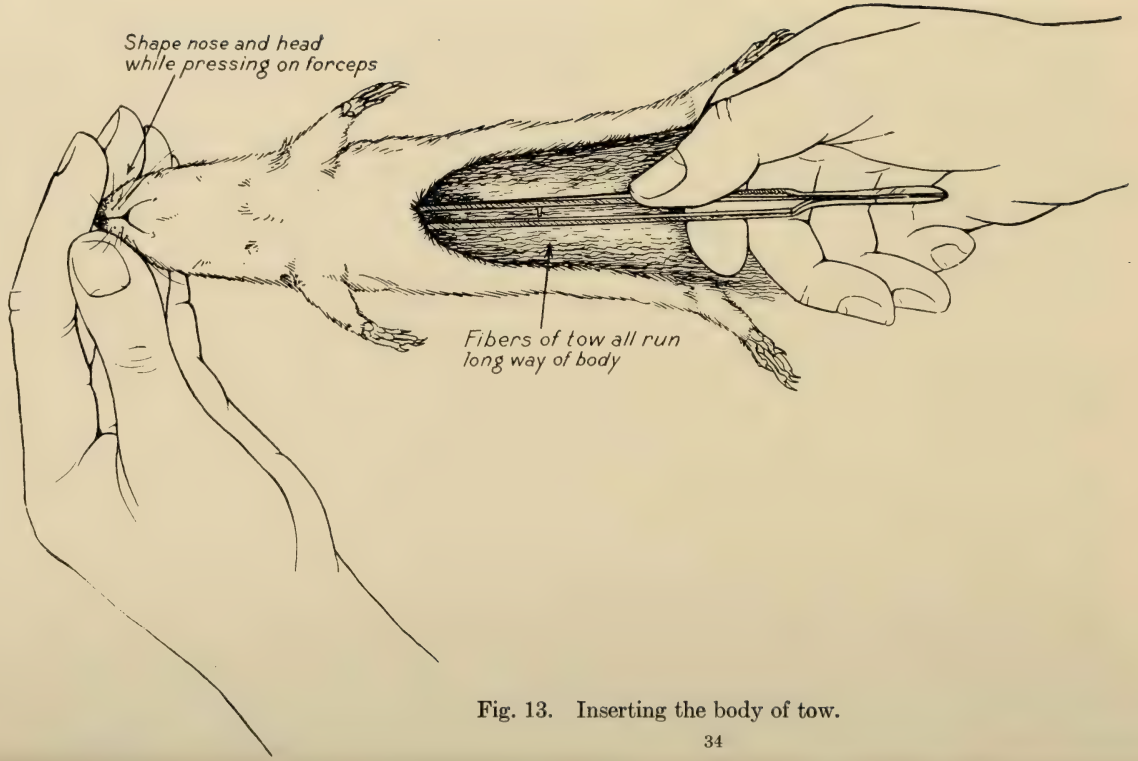


Fig. 13. Inserting the body of tow.

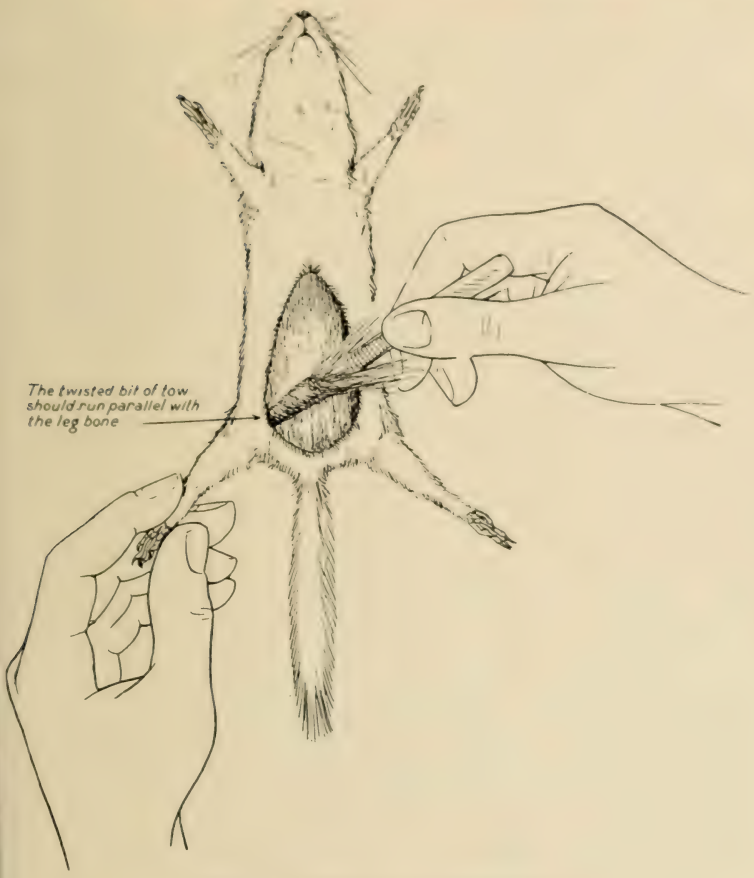


Fig. 14. Filling out the legs with tow.

time, and twirling the wire to make it lie flat. Be careful not to put on too much or you may push the tail off trying to get the wire in. By carefully working the wire down the tail it will go the full length and the part of the wire outside will slip into the cut along the abdomen. See Figure 15.

Lay the chipmunk on its belly and try a preliminary shap-

ing-up of the skin. See if it will look about as in Figure 17. It may be necessary to slip in a little more tow about the rump.

If the filling seems satisfactory the skin is then sewed up as in Figure 16. The thread will hold best if it is tied into

Fig. 15 Filling the tail with a covered wire

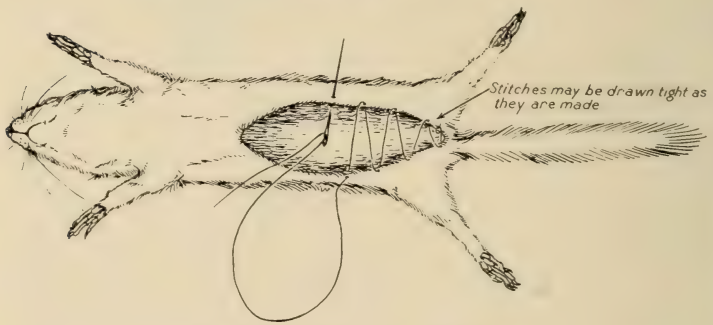


Fig. 16. Sewing up the skin.

the skin at the base of the tail. A knot at the end of the thread often pulls through. The thread should be caught with a single loop-knot where the sewing finishes off.

Take the tooth-brush and brush off any blood or dirt on the finished skin.

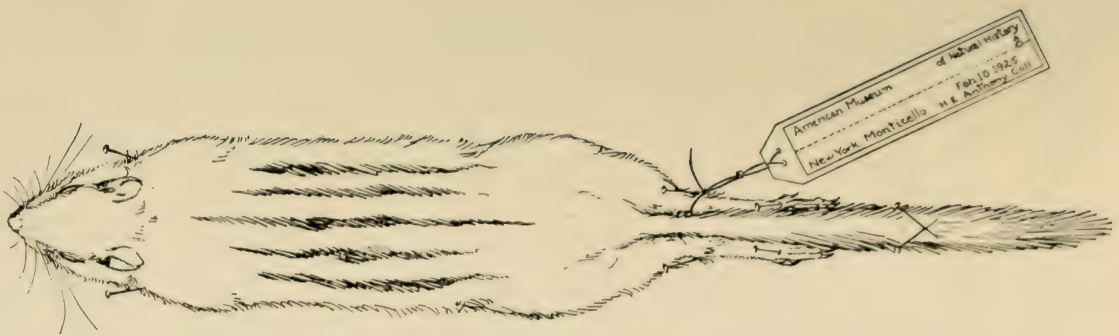


Fig. 17. The finished skin, pinned out.

Fig. 18. The finished skin, from the underside.

Tie the label, with the complete data, on the right hind leg, making a secure knot just above the heel so that the thread can not slip off.

Pin out the skin on a board, running the legs close to and parallel with the body and arranged as shown in Figures 17 and 18. The position of the pins may be seen in the figures, one in each hand and foot, one at the side of each hind leg to keep the feet in close, and two pins crossed over the tail.

Fig. 19. A skull properly labelled.

Remove the skull from the carcass by disjointing carefully at the neck. Cut off from the skull only the largest of the muscle masses in the case of medium-sized species but remove nothing from skulls of the small species. A certain amount of tissue dried onto the skull will protect it until it can be properly cleaned. Remove part of the brain with a wire, but it is not advisable to clean out delicate skulls too thoroughly in the field if they may be adequately dried. The thin vault of the cranium is very apt to be crushed unless special provision is made for its protection.

Remove the tongue and fasten to the skull a label which has the same number on it as is on the skin. It is well for the collector to add his initials to the label also. If paper labels are used, the number should be on each side of the label. No tragedy in a collector's experience is keener than the inability to match skulls with skins after they have been brought in from the field.

Do not allow skull labels to become stained with blood. Dip skulls into cornmeal; it hastens the drying and keeps the labels from adhering to the flesh. Do not dip the skulls into the arsenic-alum mixture. Do not allow blow-flies to have their own way with your skulls. The skulls may be kept on a wire and hung up to dry, out of the way of dogs or

animals. Run the wire through the loop of wire or string on the label, not through any part of the skull. Skulls may also be dried out in a small box, one or more sides of which are screened. Above all, do not allow your skulls to get wet and remain wet; they macerate or decay when wet and the resultant discolored mass may be of little use to any one, if the decomposition goes so far that the jaws drop away from the skulls and the numbers cannot be associated with the skulls.

Very satisfactory skull labels may be made from strips of block tin or monel-metal; the number may be stamped on or scratched on with a sharp tool, and if the monel-metal wire is used to fasten the label to the skull, there is little chance for the label to become illegible or to drop off.

Small skins will require about a week or ten days to dry out under normal conditions. Keep them out of the direct sunshine, but where there is a good circulation of air. In the tropics it may be necessary to dry the skins by artificial heat. If this is done, keep the specimens as far from the fire as is possible and still dry them. Too much heat will hurt them and the smoke will stain them. When thoroughly dry they may be removed from the boards, wrapped in paper, and carefully packed in some suitable container.

Collecting Chest

Sketches are shown of the type of collecting chest which I have found most useful. A regulation army locker-trunk is the foundation. This trunk comes equipped with a tray (Figure 20) which lifts out and generally rests across two transverse cleats at the ends of the trunk.

Remove these transverse cleats and fit four upright cleats at the corners, as shown in Figure 21. These cleats should be high enough to support the large tray where it belongs, at the top of the trunk. The cleats should be about five-eighths or

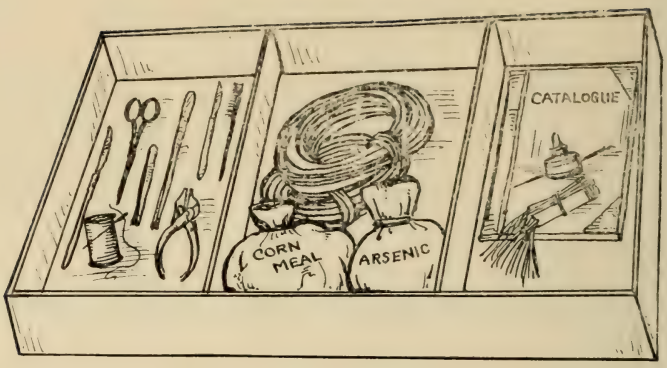


Fig. 20. The tray which rests in the top of the collecting chest

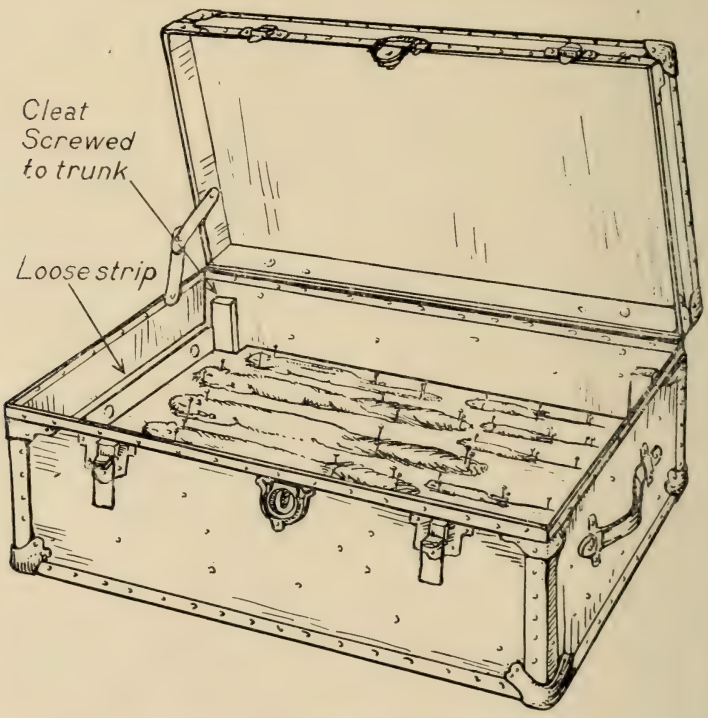


Fig. 21 A convenient collecting chest.

three-quarters of an inch in from the ends of the trunk to allow narrow strips to pass between them and the ends.

Five or six boards of thin material—I have found "compo-board" most satisfactory—are cut as shown in Figure 22 so that they will just drop easily to the bottom of the trunk. Two strips, one width of the board, are cut for each board but are not fastened to the board in any way. The width of these strips will govern the depth of the tray desired and should be

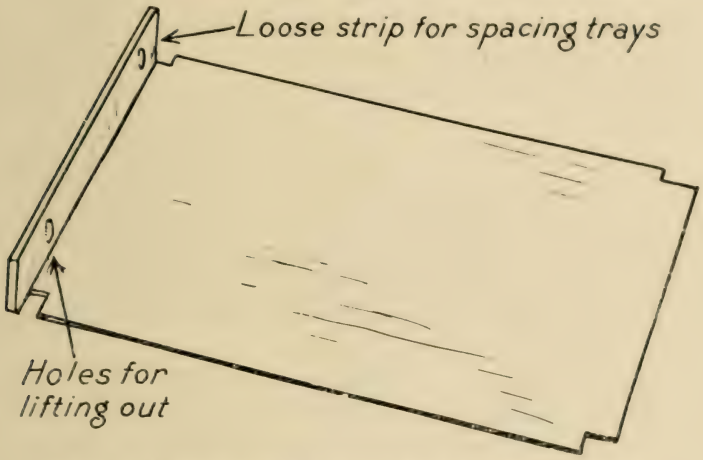


Fig. 22. A drying board with one of its two spacing cleats.

so figured that when the requisite number of boards and strips are assembled, as shown by Figure 21, the last board comes up to the level of the large tray. A useful width of strip will be one and a half inches for the average small mammal, but some may be only one inch and at least one pair will need to be three or three and a half inches wide.

The method of using these boards and strips should be obvious from the figures. The boards, when not in use, lie flat in the trunk and leave most of the trunk space available for packing. When skins are pinned out on the boards, the

boards are spaced one from another by dropping strips across the end. Holes at the ends of the strips allow the fingers to be inserted to lift the strips out.

If the skins are securely pinned into the soft wood, they will not shift during transportation. Skins should be pinned rather closer to one another than is shown in Figure 21. In placing mammals, allow for the space taken up at the end by the strip which will be inserted later. A thin layer of cotton laid upon the skins will make them still more secure when pressed down by the board of the succeeding tray.

Handy containers for dried skins are made by cardboard suit boxes. These are obtainable in flat, unassembled shape, and fit into the bottom of a locker trunk after they have been bent over at the side or end. This bending is along a line later used for the assembled box, so that no harm is done. The suit boxes filled with dry skins are later packed in whatever containers are available for shipment, and, because they may be securely packed as units, the skins come through in better shape than if they were packed directly into the large container.

When dried skins are permanently packed up they should be laid out flat and close to one another, so they can not shift about. Each skin should be wrapped carefully in a piece of paper before it is finally packed. It is advisable to separate each layer of skins by a thin sheet of cotton and to fill in any cavities with wads of cotton or tow. If the layers are very uneven, a sheet of cardboard might be employed to even up the pressure on the skins. Scatter naphthalene flakes in among the skins as they are packed.

Do not pack skulls with the skins if it is reasonably possible to avoid it. Insect life that has been feeding on the skulls may attack the skins. If skulls must be packed with skins, kill any insect life in the skulls by dipping them in a solution of arsenic and water, in weak alcohol, or even in weak formaldehyde. A short immersion kills all insects and does

not injure the skulls. Needless to say the skulls are thoroughly dried again before packing.

THE PRESERVATION OF SMALL MAMMALS ENTIRE

It is often well worth while to save entire specimens of small mammals for future dissection and anatomical study at the museum.

For this purpose either alcohol or formaldehyde may be used. For strength of solution, see page 11. Better results are obtained, however, by employing a formula that combines these two preservatives with salt.

Ethyl Alcohol.....40%
A 2% solution of formaldehyde to which has been added all the salt it will dissolve (it is well to leave a small excess of salt in the container)....60%

The specimen is opened up along the belly, the cut penetrating into the abdominal cavity so the solution may reach the viscera. Take care that the knife does not cut any of the organs. For bats and other small mammals this cut is the only preparation required and they may be dropped into the jar or can of preservative solution. Labels with full data should be tied to each specimen, of course.

In the case of larger species, it may be necessary to inject some of the solution into the mammal because immersion alone will not be sufficient. A large, injecting, hypodermic needle must be carried for this purpose. When the animal is of such a size that the body fluids may so dilute the preserving solution that decomposition sets in, the weakened solution must be replaced by fresh liquid at the end of several days.

When many small specimens are placed in one container they should be wrapped individually in a little cheese-cloth or muslin; otherwise rubbing may take the hair off.

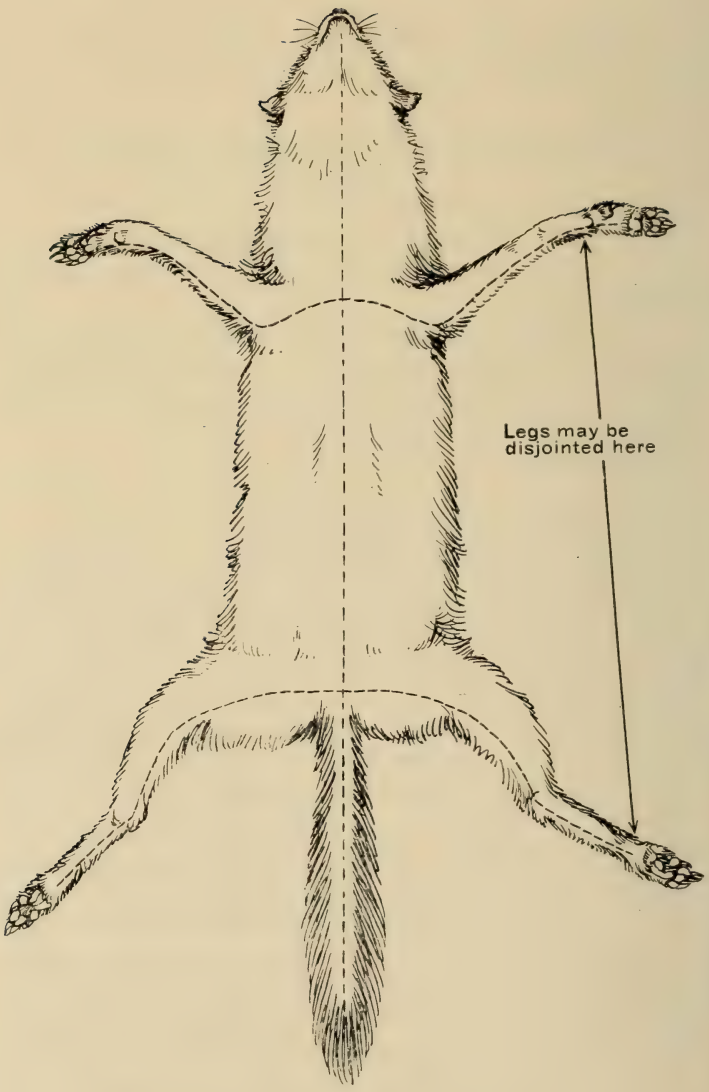


Fig. 23. Opening cuts for larger mammals.

TO SKIN A LARGE MAMMAL

If packing space is limited it may be advisable to fill out in the field nothing larger than a small squirrel. The skinning of these smaller mammals which are to be stuffed later is best done as described for the chipmunk.

Mammals larger than woodchuck, opossum or raccoon are seldom stuffed in the field. They are skinned in somewhat a different manner than that described for the chipmunk; the skin is poisoned and dried flat and is made up later at the museum.

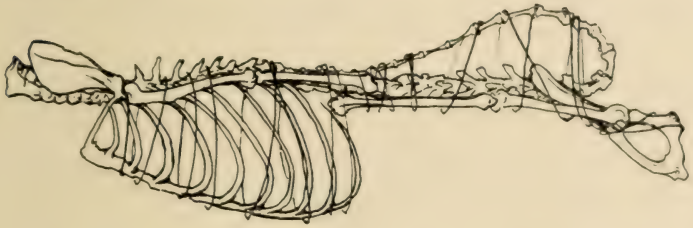


Fig. 24. Skeleton tied up for packing. This skeleton is rather better cleansed than will be necessary for the smaller mammals and a thin layer of flesh and muscles should be left to dry over the ribs and the processes of the vertebrae. The skull has been separated from the trunk in order to remove the brain.

Measurements are taken as for the chipmunk. The opening cuts are shown in Figure 23, and the skinner must be sure to work the skin free down to the tips of the ears, to the end of the nose, and to the toe-nails or hoofs. The skin is thoroughly poisoned and dried out over a cord or rope. Care should be taken that the skin does not wrinkle so that folds are closed off from the drying influence of the air. The dried skin is rolled up in a compact bundle.

Instructions for preparing the largest mammals, and the procedure to be followed in securing material to be mounted, are given in a separate publication.

Skeletons

The collecting of material for skeletons is also given in a separate publication by the American Museum of Natural History entitled, "The Preparation of Rough Skeletons," by Dr. Frederic A. Lucas. See Figure 24, showing a small skeleton prepared in the field.

In the case of very rare specimens it is often desirable to make as complete a skin as possible and to save as much of the skeleton as remains in the carcass. In this case the skin is taken off as usual, care is exercised to disjoint rather than break the limb bones, and the skeleton is prepared as described in the handbook just listed.

SAVING ODD MAMMAL SKULLS

In the majority of cases the skull is fully as valuable as the skin, and often constitutes the more valuable part of the specimen. For this reason the collector should save odd skulls, "odd" because they can not be matched with any skin. For example, a specimen may be secured in such condition that the skin is valueless and the skeleton as a whole badly broken. The skull of such a specimen might show all of the essential characters of the species and be well worth saving. Odd skulls should have a record made in the field catalogue, and preferably on the skull label as well, that the specimen is "skull only." This saves trouble later on when one looks for a skin to match.

A valuable source of odd skulls is owl pellets. Many of the owls live largely on small mammals and in the regurgitated pellets of these birds may be found skulls of practically all of the small mammal fauna of the region. From an inspection of these pellets, the collector can get a very good idea as to what he may trap for. The owl is a better collector than man can hope to be, and not a few species new to science have been based upon odd skulls obtained from owl pellets. Save all skulls found thus; they are valuable.

A good place to look for these pellets is near the entrance to caves, at the bottom of hollows in dead trees, or sometimes under limbs or cliffs where the owls have a habit of perching.

Collecting Bats

The collecting of bats presents problems quite different from those encountered in the pursuit of flightless mammals. Not only are bats difficult to secure, but they are also more troublesome for the novice to prepare as skins. Bats are exceedingly important, however, and offer more possibilities to the collector, probably, than any other order of mammals.

Only rarely may bats be trapped. Some of the fruit-eating species may be caught in traps set about ripe bananas, plan-

tains and other tropical fruits, but most of the specimens the collector secures must be shot while flying, or knocked down by sticks. Because bats ordinarily do not take wing until dusk, some of them much later, shooting must be done in uncertain light and with the added disadvantage that specimens actually hit are lost as they tumble out of the sky-line. The flight of bats is so irregular and erratic that they are extremely difficult targets and the collector must be a very good shot to get many with the gun. The best size of shot for shooting bats is No. 12, or No. 10 if they are flying high; and both the small auxiliary charge and the full size 16-gauge shell will be useful.

When bats are found in caves they are much more easily secured. Here a shot may be fired into a colony of them as they are at rest, and often one shell will bring down all the specimens required. Perhaps the passages in a cave are low and will allow a collector to reach bats with sticks or switches, and specimens may be knocked down. Bats have the habit, often, of segregating themselves in caves by sex and species. That is to say, all the individuals of a cluster or colony will be one species and one sex. This means that a few specimens should be taken in each part of a large cave in order to be sure that a complete representation has been secured. After a shot or two has been fired in a cave the bats may take wing, and such a state of confusion reigns that the collector will have no way of telling what he is collecting until the specimen is in his hand.

A net may be stretched across the entrance to a cave and the bats driven out into it. Mosquito-bar or cheese-cloth may be used for this purpose. An insect-collecting net or butterfly-net occasionally comes in handy in cave collecting.

Some species like to fly back and forth over the water and are thus more easily found when shot because they fall into the water. If the water is still or slow-moving, and one is able to retrieve what he shoots, such a collecting site will

prove very valuable. Little clearings in the forest or open meadows will also be good places to watch for bats.

Bats may frequent dwellings or old buildings and are secured by much the same methods as are employed in caves, namely, shooting, knocking down by switches, or netting. Hollow trees in the forest may be the home of desirable species which can be smoked out by a fire and shot or netted as they emerge.

Some of the rarest species of bats are forest dwellers and spend the day hanging in thick clusters of leaves or where two or three leaves hang together to make a shady nook. Such dark spots are made when a banana or plantain leaf is broken across the mid-rib by the wind and hangs down, in shape like an inverted V. At the apex of the V there may be a bat or two and a shot may be fired on a venture with a fair chance of success, if the collector is in a good bat country.

Bats are skinned just as the chipmunk was skinned, see page 26, but may be more troublesome at first because of their somewhat different body-shape and the presence of wings. Be sure to break the wing at the humerus so that the elbow joint is left in the specimen, and when making up the skin remember to leave the elbow in a position to afford the measurement of the forearm, to be taken from the dried skin later.

No difficulties will be encountered in stuffing the skins of bats, but the collector may be troubled when he attempts to pin the specimens out to dry. Pin the bat out with the back up, belly to the board, just as with the chipmunk. Set the wings close to the body by a pin through the wrist, drawing the wrist close up to the neck and body. Bring the thumb with its sharp, tiny claw, back against the wing, so that it does not stick out to catch on things. The long finger joints or phalanges will tend to arrange themselves in a natural order, running backward from the wrist close together and parallel. A pin or two at the tips of the wings helps to hold the wings in place.

The hind legs are generally pinned farther apart than would be the legs of a rodent, for example. This is to allow for a better display and arrangement of the interfemoral membrane which extends from leg to leg and may include the tail.

Instructions are given elsewhere for preserving bats as alcoholic specimens.

Miscellaneous Hints

After one has prepared a few small mammals, various short cuts in procedure may suggest themselves. Individual deviations from the practice described in this handbook may be worked out without detracting in any way from the satisfactory nature of the final result.

I find it easier to break the legs of small mammals with my fingers, thrust the broken end of the limb bone through the flesh, and strip the meat off, rather than to disjoint the legs.

Short wires may be cut for the legs. These wires are twisted into the filling for the leg, thrust into place and left there. This makes a very strong leg and is excellent practice.

In making up skins of rabbits and hares it will be necessary to use a long wire running from the toes of the forefoot to the toes of the hind foot. The skin of these animals is so delicate that the legs will break off unless such a wire is used. If one end of the wire is sharpened, it may be thrust clear through the forefoot far enough to allow the other end to be inserted into the hind leg.

It may be more convenient to remove the skin and clean the meat from the legs as a final process, cutting the legs free from the body with scissors at the moment of skinning.

If pressed for time, with many specimens to save, I often skin everything before beginning to stuff the specimens. This practice may save mammals on the verge of decomposition. The poisoned skins turned right side out are kept in a box or placed where they can not dry out too fast before they are stuffed.

The tails of some species will not strip readily from the vertebræ and must be split along the underside their entire length. This is true of the skunk and the porcupine.

MISCELLANEOUS DATA FOR LABELS OR NOTEBOOKS

All data not already well known, such as notes on food, life-histories, or details of soft structures which are not discernible in a dried skin, should be set down on the label, or in the field note-book if too voluminous for the small space available on the label. Facts that are known to be well established do not call for special notes, but it is well worth while to have some sort of record of even seemingly trivial data because we know so little of the life-histories of most of our small mammals.

Unless one is a specialist in such matters, it is difficult to identify stomach contents of small mammals while in the field. A specimen or two in alcohol, or simply the stomachs themselves in preserving fluid, may be saved for a later examination in the laboratory. However, it is often possible to discover on what the mammals have been feeding by an examination of food in mouth or cheek-pouches before it has been chewed into fine particles. Perhaps the food of a species can be discovered in its runways or burrows.

The condition of the sexual organs is worth noting, as this has a bearing on the breeding season. The number and stage of development of any fœtuses found should be noted on the label. If the mammary glands of a female show the animal is nursing, record it so on the back of the label. The number and location of the mammæ might be recorded as well, especially if there is reason to believe that the specimen is of a rare or little-known species.

Often the arrangement and number of the pads on the feet are different in closely allied forms, and it is of importance to know the condition of the plantar and palmar surfaces. In a dried specimen it may be impossible to make out from the shrunken foot whether the mammal had five or six plantar pads, for example. This is readily apparent if the animal is

examined in the flesh and should be noted on the label if the specimen is suspected to be a rare or unknown species.

Many of the external characters of bats are either lost or so distorted in a dried specimen as to be of little value. Structures on the nose and ear especially should be examined and any peculiarities noted on the label or in the note-book. So important are these structures in identifying bats that it is highly desirable to save some of each species in alcohol or formaldehyde. A good rule is to save the first specimen of each distinct bat collected, as an alcoholic. Then if no more are secured the maximum amount of data can be obtained from the one specimen.

GUARDING AGAINST ANTS

Often in the tropics ants will prove decidedly troublesome and no very satisfactory methods have been evolved to escape them. Skins may be protected by naphthalene, paradichlorbenzene, or insect-powder, as has already been pointed out, but there is no way to keep ants from attacking the bait in the traps or the specimens caught by the traps.

Any substance placed upon the bait to render it unattractive to ants has an undesirable effect upon the appetities of the mammals one wishes to catch. If a trap-line can be run only once a day the ants may carry off all the bait before a mammal has the opportunity to visit the trap. If it is possible to rebait the traps late in the afternoon it is well worth doing so.

The greatest damage done by ants is upon the trapped mammal, which is sometimes injured beyond all hopes by the time the traps may be run in the morning. If the collector can visit part or all of his trap-lines about 9 or 10 o'clock in the evening, he can prevent the ravages of the ants from assuming such disastrous proportions. If the mammals could be trapped alive probably many of them would be able to fight the ants off, but it should be remembered that ants have been already attracted to the spot by the bait and

are apt to devour a small creature in confinement. In any event, it is out of the question for the collector who is working in out-of-the-way places to carry an extensive line of the bulky live-traps.

When first collecting in a locality it is important to save the first specimen of each species taken, regardless of its condition. It may be the only one taken during the entire stay. Later, when damaged specimens of a species demonstrated to be common are taken, they may be discarded or made into skeletons. If the ants have attacked only the soft parts the specimen may still be perfectly satisfactory as a skeleton. It may be best to preserve an ant-damaged specimen in formaldehyde or alcohol, if a series of holes have been eaten in the skin.

A more extensive account of some of the points taken up in this handbook is given in "Taxidermy and Museum Exhibition," by John Rowley, published by Appleton & Co., of New York City.

MATERIAL TO BE SENT TO THE AMERICAN MUSEUM

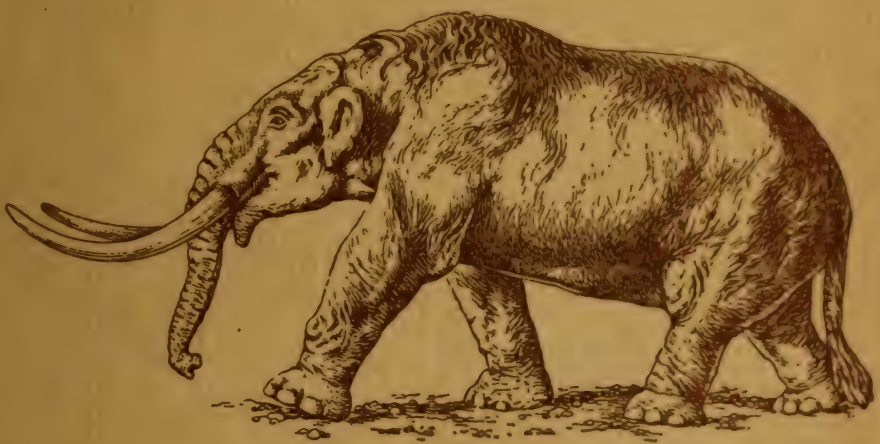
Mammal skins to be sent to the American Museum should be well dried, carefully packed in strong, tight boxes, with some substance like naphthalene to keep out insects, and shipped in such a manner that the specimens can not be damaged by heat or water. Sometimes boxes may be packed near boilers on the steamer or left out on the deck. Either practice will be injurious to skins. Address the box plainly to

American Museum of Natural History,
New York City,
U. S. A.

Any questions of customs duties or entry into the United States will be taken up and arranged for by the American Museum.

THE AMERICAN MUSEUM OF NATURAL HISTORY

MASTODONS AND MAMMOTHS OF NORTH AMERICA



By HENRY FAIRFIELD OSBORN

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Group of American mastodonts (*Mastodon americanus*) along the banks of the Ohio River, where these animals were first discovered in 1739. After restoration by Osborn and Knight.

The Elephants and Mastodonts Arrive in America

By HENRY FAIRFIELD OSBORN
President of The American Museum of Natural History

Foreword.—Among the treasures of the American Museum is the unrivaled collection of skeletons and skulls of fossil proboscideans from Africa, the home of the race, from Asia, and from North and South America. Aided by the Morgan and Jesup funds, a large volume is being prepared describing the whole history of the elephant and mastodont families as far as known today. The present article is a sketch of these remarkable animals as they migrated, one race after another, into America, became naturalized and acclimated, enjoyed their lives here, and finally became extinct, the last survivor being the great mastodon of the eastern forests of North America.

THERE are few joys in life comparable with that which the naturalist experiences when one of his predictions or prophecies happens to be fulfilled. In 1900 I predicted that Africa would prove to be the cradle of the Proboscidea; in 1903 this prophecy was verified by British explorers in Egypt. Naturally eager to visit the scene of this discovery at once, I refrained until my British friends had fully described and published this and other discoveries and gained the world-wide reputation therefor to which they were richly entitled. I then asked President Theodore Roosevelt for an introduction to Lord Cromer, at the time Viceroy of Egypt, and through the generosity of President Jesup of the American Museum an expedition was fitted out, carrying as credentials a thoroughly characteristic note from President Roosevelt to Lord Cromer. Unfortunately, I did not keep a copy of the note but, so far as I recall, it ran as follows:

January, 1907.

Dear Lord Cromer:

The bearer, Henry Fairfield Osborn, is a friend of mine keenly interested in palaeontology who desires to enter the Fayûm district of Egypt. Any help which you may be able to extend to him or to his party will be greatly appreciated by

Yours sincerely,

Theodore Roosevelt.

This brief and simple diplomatic message opened the doors of Egypt to the American Museum party. On our arrival at Shepheard's Hotel on the morning of January 23, a card was sent up announcing Captain H. G. Lyons, then director of the Geological Survey of Egypt, who thereupon as-

sured me that all the resources of the Survey would be placed at our disposal,—a camel caravan, a supply of the absolutely essential *fantasses* for carrying water, and, best of all, the guidance of a most intelligent and delightful member of the Survey staff, Mr. Hartley T. Ferrar. A personal caravan was also engaged. Thus, sixty camels strong, we wound our way past the pyramids of the eastern side of the Nile, skirted the fertile basin of the Fayûm, and struck southwest into the waterless desert until we reached the region that represented the ancient cradle of the elephant family. We at once set to work with a very superior force of Egyptian excavators from Kuft, under the direction of Mr. Walter Granger and Mr. George Olsen, two of the best fossil hunters of America, who stuck to their arduous post for nearly two months, until driven out by sandstorms and excessive heat. With their skilled aid, we soon discovered the burial sites of three of the early elephant dynasties; the Mœritherium, the abundant Phiomia, and finally the rare Palæomastodon. The last-mentioned name is derived from the uncorrupted Greek words παλαιός, μαστός, and ὀδούς, signifying "the ancient nipple tooth." This name, applied by the able British palæontologist, Charles W. Andrews, recently deceased, has proved to be of literal significance because we now have reason to believe that *Palæomastodon* may be the direct lineal ancestor of our true American mastodon (*Mastodon americanus*). Thus for the American Museum was disinterred a superb collection of small ancestral mastodonts, remote and humble relatives of three branches of the mastodont family—all of Upper Oligocene time, estimated by some geologists as 3,000,000 years ago.

The Fayûm Expedition took place seventeen years ago. It aroused in the writer's mind the liveliest interest in these relatively small and primitive proboscideans, and a desire to compare them closely with the large proboscideans of France and South America, which were first described in 1806 by the famous Cuvier, also the wish to compare them with the proboscideans described and figured by the British explorers Falconer and Cautley in India between the years 1845 and 1847, and finally the hope to trace all these animals from their ancestral homes in Africa and Eurasia through their migrations to America.

TRAVELING INSTINCTS OF THE PROBOSCIDEANS

An insatiable *Wanderlust* has always possessed the souls of elephants as it has those of the tribes and races of man. Not only to overcome the changes and chances of this mortal life, but also to gratify their intelligent curiosity ever to explore afresh forests, pastures, fields, rivers, and streams, they have gone to the very ends of the earth and have far surpassed man in adapting their clothing and teeth to all possible conditions of life. Thus the romances of elephant migration and conquest are second only to the romances of human migration and conquest. Variety is the spice of elephant life, as it is of human life, and the very longing for a change of scene and of diet has been the indirect cause of what in scientific parlance we term *adaptive radiation*—the reaching out in every direction for every kind of food, every kind of habitat, in itself the *cause* of radiating or divergent evolution and adaptation. It is to this predisposition to local, con-

tinental or insular, and world-wide wanderings that we attribute the many branches and sub-branches which have been developed in this remarkable family. We may first enumerate all these branches and then signalize those that found their way to America and which form the chief subject of this article.

PROBOSCIDEA

Races I–X of the Mastodont Family: Mastodontidæ

I. The Moeritheres, named from Lake Mœris of the Greeks. Small amphibious mastodonts of the North African rivers and lakes. See figure p. 9.[1]

II. The Dinotheres, implying proboscideans of terrifying size. Existed in Europe and Asia in Miocene and early Pliocene times.

III. The True Mastodonts, arising from *Palæomastodon* of the Egyptian Oligocene. Sparsely represented in the forest and lignitic deposits of Europe; first appearing in America in Upper Miocene time, becoming the giant mastodons of the American forests at the close of the Ice Age. See figure p. 12.

IV. The Yoke-toothed Mastodonts, or Zygolophodonts. First known in the Miocene of Europe and leading into Borson's mastodon of the Upper Pliocene forests of Europe and Asia, close to the true mastodonts.

V. The Long-jawed Mastodonts, or Longirostrines, springing from the long-jawed *Phiomia* of the Egyptian Oligocene and becoming the *Trilophodon* of Europe, migrating through Europe and Asia in the Miocene and spreading over Nebraska, Kansas, South Dakota, and Colorado in Pliocene time. See figures pp. 10 and 11.

VI. The Tetralophodonts, the name referring to the four ridge crests on the anterior molar teeth. First known from the Lower Pliocene of Eppelsheim, Germany, and of Pikermi, Greece; migrated across India, and entered America in late Pliocene time during the beginning of the Ice Age.

VII. The Serridentines, named in allusion to the serrations on the outer and inner borders of the grinding teeth; medium-jawed. First known in the Miocene forest deposits of Europe; migrated to our southern states, Texas and Florida, and survived to the very close of Pliocene time. See figure p. 13.

VIII. The Beak-jawed Mastodonts, or Rhynchorostrines, readily distinguished by the downward curvature of the tusks, similar to that in the Dinotheres. Of unknown European origin; first discovered in Colorado and California, and traced down into Mexico.

IX. The Nototostrines, name signifying 'mastodonts of the south' because the animals are found chiefly in California and South America. Short-jawed, the like true mastodons.

X. Extremely Short-jawed Mastodonts, or Brevirostrines. First known species, the straight-tusked mastodont of Auvergne, Pliocene of France. The Brevirostrines migrated to India, reached western Nebraska in Middle Pliocene time, and survived in our southern states into the beginning of the Ice Age. See figures, p. 15.

Races XI–XVI of the Elephant Family: Elephantidæ

XI. The Stegodonts, named because of the resemblance of the toothed rodges of the grinding teeth to a series of roof-gables are more primitive than the true elephants. The Stegodonts have been traced from the Miocene of Europe into the forests of India and the Eats Indies to China.

XII. The African Elephants, or Loxodonts, distinguished by their lozenge-shaped grinders. See upper figure p. 18. Related forms attained gigantic size in southern Europe and in India, dwarfing into the diminutive species of the Mediterranean islands. See lower figure p. 6.

XIII. The Southern Mammoths (*Archidiskodon*, signifying ancient crested). First known in India, migrating westward into southern Europe, eastward by Bering Strait into America, where they arrived in early Glacial time, and gave rise to the imperial mammoth. See figure p. 20.

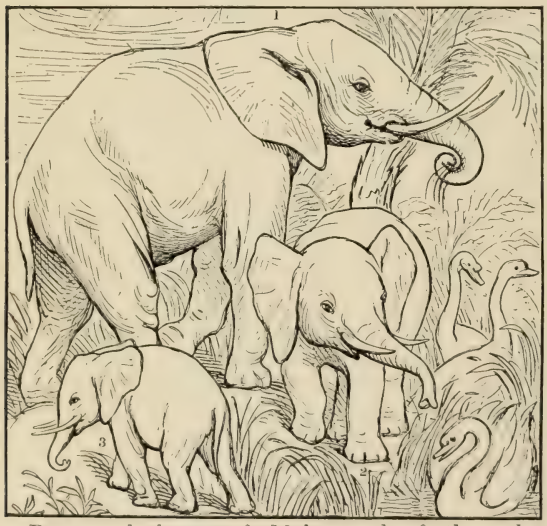
[1]The series of illustrations throughout the article are all to a uniform scale, with the exception of the headpiece and tailpiece.

XIV. Parelephas, signifying a collateral to the true *Elephas*. Mammoths of the temperate zone. First known in Europe, traced into America, where they arrived in mid-Glacial time, and gave rise to the great Jeffersonian mammoth.

XV. The Woolly Mammoth (the *Elephas primigenius* of Blumenbach). First discovered in northern Germany and in England. It crossed northern Asia, and arrived in America in late Glacial time. See figure p. 21.

XVI. The True Elephants (the *Elephas* of Linnæus), probably originating in northern Asia. First known in India early in the Age of Man, and giving rise to the recent species of India, Burma, and Ceylon. See lower figure p. 18.

African home of the primitive mastodonts.—The word "Proboscidea" as printed 1900 and supplemented in the present map by the black dot (●) indicates the Fayûm Desert of Egypt, where these animals were discovered in 1903



Pygmy elephants of Malta and of the other Mediterranean islands, as restored by Leith Adams in 1870, namely, 1, *Loxodonta (Pilgrimia) mnaidræ;* 2, *L. (Pilgrimia) melitensis;* and 3, *L. (Pilgrimia) falconeri*, the smallest $\frac{1}{50}$ natural size

So strong was the migratory impulse that only six out of these sixteen races of mastodonts and elephants failed to reach America. The Stegodonts (Race XI), one of these six groups of 'stay-at-homes,' were confined, according to the writer's theory, to the warm southern forests of India, to China, Japan, and the East Indies, when these islands were connected with the mainland. The true African elephants, or Loxodonts (Race XII), never left the African continent, although the somewhat closely related pygmy elephants of the Mediterranean islands (see lower figure on this page) and the giant straight-tusked elephants of India and southern Europe were great travelers. The true Indian elephant (Race XVI) never went beyond the confines of Asia, and its Asiatic ancestors still await discovery; their probable home land was in the great northern plateaus and forests. The amphibious Mœritheres (Race I) were closely bound by their river habitat to Africa and thus far have not been recognized elsewhere. The Dinotheres (Race II), notwithstanding their long limbs and gigantic size, wandered only east and west in their European and Asiatic homelands. The yoke-toothed

Theoretic migration routes of the mostodont family from their center (•) in Africa to all of the continents excepting Australia. The cradle of the elephant family is still unknown

Actual migration routes of the long-jawed mastodonts (Longirostrinæ) and of the true mastodon (Mastodontine) from their actual center of origin in north Africa as indicated by their respective symbols. Note also the migration routes of the Brevirostrines, Notorostrines, and Rhynchorostrines

mastodonts,' or Zygolophodonts (Race IV), never reached America and are not treated fully in this article.

The successive times of departure and arrival of the ten wandering races as contrasted with the 'stay-at-homes

cannot be fixed exactly. En route from Asia to North America, they were all forced to come by way of the northern Bering Strait, then an isthmus. Some races, like the 'beak-jawed mastodonts,' are very rare and are as yet known only by a few specimens, which are of highly characteristic and easily distinguishable form and associated habit. All the arrivals were naturally subsequent to the early evolution of the sixteen races of proboscideans in the African and Eurasiatic continents. In some cases the migrations appear to have been gradual; for example, the 'long-jawed mastodonts' (Race V), as represented by *Phiomia*, appear in the Oligocene of Egypt; they spread all over Europe in Miocene time, and were fairly abundant in Nebraska and Colorado in Pliocene time. At the other extreme are such instances of rapid traveling as that represented by the southern mammoth, which appears in the Upper Pliocene of Europe and in the advancing Ice Age of North America. Next in point of interest is the evidence of strong climatic preferences; it would appear that the south temperate and north temperate races of elephants sought corresponding and congenial life zones for their prevailing habitat, as do the Italians, the Germans, and the Scandinavians in the human migrations of our day.

Thus three kinds of mammoths are distributed on different isotherms, as indicated in the table herwith.

Proboscideans have always been fastidious in their feeding habits. Consistent with their choice of similar isotherms conditioning the flora and fauna of their times, these clever animals coming from the Old World also sought out similar habitats in America, whether of northern or southern forests, savannas, stream borders, or more or less arid and desert zones. For example, we have proof of the arrival of Race X (the Brevirostrines, genus *Stegomastodon*) in the rapidly desiccating areas of western Texas and western Arizona, where they competed for food with other desert-loving forms, like the horses, the camels, and the armored glyptodonts (*Glyptotherium*) of South America. Superb adaptations to these different degrees of temperature, different kinds of food, and more or less moist or arid atmosphere appear not only in the tusks and in the grinding teeth (which are beautifully preserved in the fossil condition), but also doubtless in the unique shaping of the upper lip into the organ known as the proboscis, which gives these animals their ordinal name Proboscidea.

RACE I, THE MŒRITHERES, AND RACE II, THE DINOTHERES

THE MŒRITHERES (RACE I).—These are the oldest proboscideans known at present, the most primitive and diminutive. Their remains occur in the estuarine and fluviatile sands of the primordial river Nile, which the German geologist, Blanckenhorn, named 'Ur-Nile.' The pair of enlarged upper and lower tusks abrade each other as in the hippopotami; were it not for the fact that these teeth are comparable to the pair of incisors

CLIMATIC TABLE

Kinds of Mammoths	Eurasia	America
XV. WOOLLY MAMMOTH	Boreal and circumpolar habitat	Boreal habitat and borders of glacial ice sheet
XIV. TROGONTHERIAN MAMMOTH (*Parelephas*)	Mid-temperate regions	Mid-temperate regions
XIII. SOUTHERN MAMMOTHS	South temperate: *Elephas meridionalis*	South temperate: imperial mammoth (*Elephas imperator*)

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Mœritherium on the borders of the primitive river Nile, now the Fayûm of Egypt. After restoration (1907) by Osborn and Knight; $\frac{1}{50}$ natural size

enlarged into tusks in all other proboscideans, and that the grinding teeth are also comparable to the grinders of all the higher mastodonts, we might question the relationship of these animals to the higher proboscideans, because their amphibious habits separate them so markedly from the other members of their order. They disported abundantly in the Ur-Nile but are not known to have migrated into Europe or to have left descendants.

THE DINOTHERES (RACE II).—Teeth, jaw fragments, and an astragalus of the Dinotheres had been found and described between the years 1715 and 1758, but it was not until 1828 that the famous lower jaw, named by Kaup in 1829 *Dinotherium giganteum*, was discovered at Eppelsheim, Germany. The Dinotheres appear abundantly in the Miocene of Europe and we are inclined to believe that they sprang from African ancestors, because one of these ancestors has recently been discovered.[1] As they are distinguished by sharply crested teeth and by a pair of huge down-turned lower incisive tusks, it was long supposed that, like the Mœritheres, they too were amphibious in habit, but this hypothesis has been weakened by the discovery of a complete skeleton, which shows that these proboscideans had very tall limbs, with high body proportions altogether different from those of the Mœritheres and of the existing hippopotami; in fact, all amphibious mammals have either short limbs or no limbs at all. Whatever their habits and special habitat, the Dinotheres attained gigantic size, as evidenced by the *Dinotherium gigantissimum* of Roumania. They reached India, but thus far there is no evidence of their having penetrated as far as China and still less of their having approached the American continent.

RACES V AND III. THE LONG-JAWED MASTODONTS AND THE TRUE MASTODONS

THE LONG-JAWED MASTODONTS (RACE V).—These animals derive their scientific name 'Longirostrines' from their extremely long and slender jaws, which far surpass in length those of any other land mammal thus far discovered. At the extremity of the lower jaw is a pair of shovel-shaped lower tusks, and there is no doubt that these tusks were used, after the manner of a trowel or spade, in the digging out and uprooting of plants. That this unique function gave these animals very great advantage over their rivals is demonstrated by the rapid spread of the Longirostrines eastward into India, thence northward into China and America, and all the while they were increasing in size and power until as a culmination the massive animal known as *Tri-*

[1]This is *Dinotherium hobleyi* from the east side of Victoria Nyanza, described in 1911 by the late Charles W. Andrews, of the British Museum, found in beds attributed to Lower or Middle Miocene age.

lophodon giganteus, discovered by Mr. Troxell in South Dakota, attains a height nearly equaling that of our giant American mastodon. It is difficult to believe that this giant springs from the relatively slender North African Longirostrine, to which the name *Phiomia* has been given in reference to the proximity of its former habitat to the Fayüm of Egypt, the Phiomia of the Greeks; yet when we examine minutely the horizontally placed upper and lower tusks of *Phiomia*, the long narrow grinding teeth harmonic with the long jaw, and the three crests of the intermediate grinding teeth, there can be little doubt that *Phiomia osborni* is a progenitor of the race that gave rise to the *Trilophodon angustidens* of Europe, to the *Trilophodon palæindicus* of India, and to the numerous long-jawed species recently discovered in South Dakota, Nebraska, and Colorado by Prof. Erwin H. Barbour of the University of Nebraska, by Mr. Harold Cook of western Nebraska, and by Mr. E. L. Troxell mentioned above.

In these American Longirostrines the elongation of the lower jaw and tusks reaches the incredible extreme of six feet, seven inches in the species *Trilophodon lulli*. Jealous of her endowments, nature kept the grinding teeth of these animals in very simple condition, hardly more complex than those of the Egyptian *Phiomia*, in which the jaw measures two feet six inches. To our mind, the Longirostrine relied very largely upon their superior and inferior tusks for the gathering in of food, which was rapidly masticated and readily swallowed because of its relatively succulent nature.

THE TRUE MASTODONS (RACE III).—The true mastodons of our American forests appear to have arisen from the diminutive *Palæomastodon* of the primordial river Nile. The reason these animals have left no trace of their 10,000-mile and 2,000,000-year journey from the Nile region to the forests bordering the Ohio and the Hudson rivers is that fossilization of forest-living fauna has always been rare. The ancestral *Palæomastodon* of the Nile region is itself very rare; in the American Museum collection there are forty-eight specimens of the long-jawed *Phiomia* to seven specimens of *Palæomastodon;* not even fossilized teeth of this race were scattered in Europe to show the route. Thus, while the woolly mammoth left an overwhelming number of fossilized remains which were discovered in western Europe from the end of the eighteenth century onward, the true mastodon was first found on the banks of the Hud-

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Long-jawed mastodont (*Phiomia osborni*) on the borders of the primitive river Nile, now the Fayûm of Egypt. After restoration by Osborn and Knight; 1/50 natural size

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Long-jawed mastodonts (*Trilophodon giganteus*) from the Lower Pliocene beds of South Dakota. After restoration by Osborn and Knight; 1/50 natural size

son (1705) and the Ohio (1739). The Ohio fossils were fully characterized by the great French naturalist Buffon as a distinct species belonging to the epoch of the elephants although Buffon did not give the animal a name. Johann Friedrich Blumenbach, who named the woolly mammoth *Elephas primigenius* in 1799, in the same communication placed the name OHIO-INCOGNITUM beneath the figure of the tooth of the American mastodon. These animals now rival the mammoth, as the best-known of all the extinct proboscideans; thousands of teeth and jaws, as well as more or less complete skeletons have been found, chiefly in the Fourth Glacial swamps and marshes of our Middle and Eastern States.

In contrast with the long-jawed mastodonts, the true mastodons are short-jawed. Their lower tusks are

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True mastodon (*Mastodon americanus*) from the Pleistocene beds of New York. After restoration by Osborn and Knight; $\frac{1}{50}$ natural size

variable; the upper tusks curve upwards and inwards, like those of the elephants, and served for uprooting plants and for defensive and offensive purposes, while the proboscis was the main 'food getter' for the huge bodily frame.

RACES VI, VII, AND VIII. TETRALOPHODONTS, SERRIDENTINES, AND BEAK-JAWED MASTODONTS

THE FOUR-CRESTED MASTODONTS (RACE VI).—In 1832 Europe was greatly stirred by the discovery in the Lower Pliocene of Eppelsheim, Germany, of a mastodont with *four* instead of *three* ridge crests on its intermediate grinding teeth. Hugh Falconer based upon this character the appropriate name *Tetralophodon* (i.e. four-crested teeth) as distinguished from *Trilophodon*, the designation of the mastodonts with three ridge crests. In these animals with four-crested teeth the jaws are not so extremely elongated for shovel and spade work as in the long-jawed mastodonts (Race V), but by way of compensation, the grinding teeth became much more complex because they had to do far more work. While the back grinders of the long-jawed mastodonts remain very simple and never exceed four and a half ridge crests, the back grinders of the Tetralophodonts rise to seven and a half ridge crests and become adapted to their very long and arduous life work, culminating in the stage which the writer has named *Tetralophodon* (*Morillia*) *barbouri*, after Dr. Erwin H. Barbour, the geologist and explorer, and the Honorable Charles H. Morrill, patron and benefactor of the exploration of the extinct life of Nebraska. The Tetralophodonts are in all coun-

tries very rare, yet we can trace their long migration through eastern Europe into India and China, until finally they arrive in Kansas and Nebraska. The jaws remain of medium length, the lower tusk is not as yet known; the upper tusk curves downwards and outwards.

THE SERRIDENTINES (RACE VII).—The Serridentines, or 'serrate-toothed mastodonts,' have only recently, as a result of investigations of the writer, become distinguished from the long-jawed mastodonts, on the basis of the structure of the relatively few teeth found in ancient forest or lignitic deposits of France, Switzerland, and Austria. Yet these few teeth afford indubitable proof that these Serridentines are not to be confused either with the long-jawed mastodonts (= *Trilophodon*) or with the medium-jawed mastodonts (= *Tetralophodon*). They form a race of their own, to which the generic name *Serridentinus* has been given. En route to America one member of this race succumbed and left his jaw to become a fossil on one of the ancient rivers of Mongolia, and here it was unearthed by the Third Asiatic Expedition in 1922 and subsequently christened *Serridentinus mongoliensis*. Eight thousand miles eastward and southward of this spot, which is in the desert of Gobi, the Americanized descendants are found in the marls near Santa Fé, New Mexico, and in the ancient river sands near Clarendon, Texas, in a formation of Lower Pliocene age. A beautiful restoration, made under the direction of the writer, from a nearly complete skeleton of a Serridentine of northern Texas is reproduced above. It shows the animal reaching for foliage with its proboscis, aided by a lower jaw with tusks of medium length, a jaw more elongate than in the true mastodons but less elongate than in the extremely long-jawed forms.

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Serrate-toothed mastodont (*Serridentinus productus*) tree-browsing; as found fossil near Clarendon in northern Texas. After restoration by Osborn and Knight; natural size

THE BEAK-JAWED MASTODONTS (RACE VIII).—The 'beak-jawed mas-

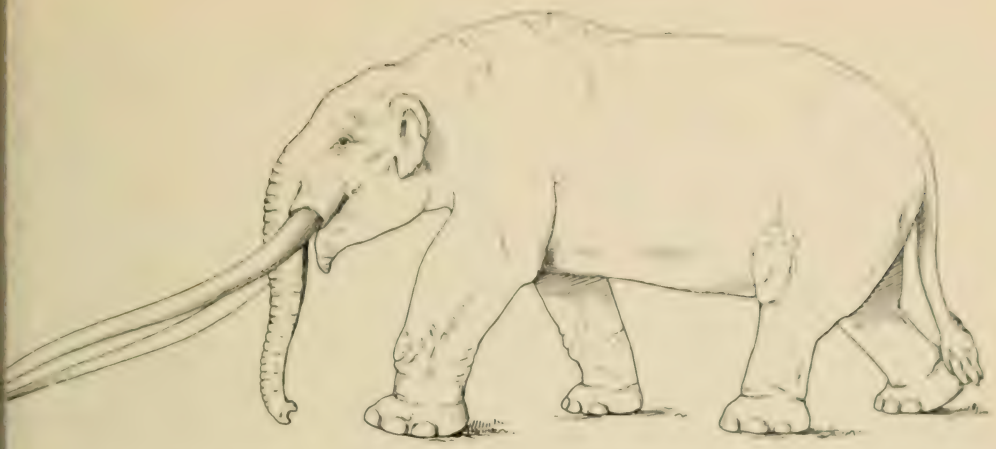
todonts,' technically known as Rhynchorostrines, are readily distinguished from all other mastodonts by the sharp downward curvature of the anterior portion of the jaw into a beaklike prolongation, in which are inserted two downwardly pointed tusks flattened on the sides. It was due to this unique adaptation of the jaw and tusks for uprooting plants and roots that Falconer in 1856–68 applied the name *Rhynchotherium* to the animal under the following circumstances: "At Genoa I saw a cast of a large lower jaw of a Mastodon from Mexico, with an enormous *bec* abruptly deflected downwards and containing one very large lower incisor. The beak is much thicker than in *M.* (*Trilophodon*) *angustidens* and larger than in *M.* (*Tetralophodon*) *longirostris*. You know that every one (Laurillard, Gervais, etc.) has insisted on the absence of the lower incisors from both of the South American species. The outline of the jaw resembles very much the figure in Alcide D'Orbigny's Voyage, described by Laurillard as *M. Andium*. The specimen is unpublished material and I was therefore only allowed to examine it very cursorily. The Genoese palæontologists had provisionally named it *Rhynchotherium*, from the enormous development of the beak, approaching Dinotherium."

Very few remains of this 'beak-jawed mastodont' have been discovered, and it has required long study to work out the peculiar adaptations of the dentition which consists of down-turned upper and lower tusks and of very broad and simple upper and lower grinding teeth. Traces of the 'beak-jawed mastodonts' occur in Oregon in Montana, in Colorado, and in California, but thus far the best-preserved jaws are those from Mexico, the region from which came the specimen that the keen eye of Falconer first recognized as a beak-jawed animal quite distinct from the 'long-jawed mastodont' of western Europe.

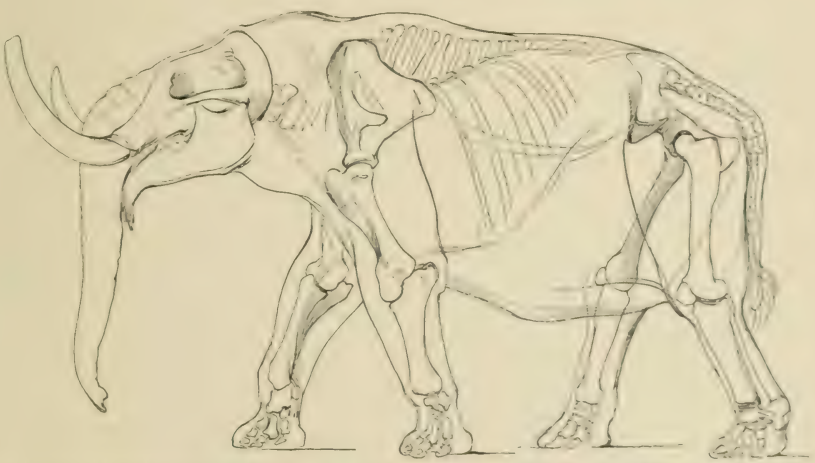
RACE X, THE SHORT-JAWED BREVIROSTRINES, AND RACE IX, THE NOTOROSTRINES

Races X and IX present a marked contrast to all the races preceding, in the shortening of the lower jaw and the disappearance of the lower tusks, which transfer to the upper tusks, the proboscis, and the upper and lower grinding teeth the whole function of collecting the food and of masticating it before it enters the long process of digestion and assimilation whereby the relatively feeble energy of plant life is transformed into the commanding energy of these proboscideans.

The back grinders, or third upper and lower molars, are, on the whole, the most characteristic part of the entire anatomy of these and other proboscideans, even more distinctive than the tusks. Many proboscideans resemble each other in the general shape of the superior tusks, which may display substantially the same curvature and shape in nine of the sixteen races which are here considered; this tendency is due to the fact that in all these races the upper tusks perform the same functions of offense and defense and are tools of great value in the uprooting of plants and small trees. It is true that there are in the tusks distinct differences of curvature and of diameter which become increasingly apparent as the animals attain old age, but the tusks of the young of the Indian elephants, of the woolly mammoth, of the Jeffersonian and of the imperial mammoths, of the African elephants, and of the Stegodonts are not readily distinguishable from the upper tusks of the true mastodons nor from the two tusks of the short-jawed



Short-jawed mastodont of southern Arizona (*Stegomastodon arizonæ* Gidley), as discovered by J. W. Gidley in the San Pedro beds. After restoration by Knight; 1/50 natural size



Short-jawed mastodont of Auvergne, France, (*Anancus arvernensis*), highly characteristic of the Upper Pliocene of Italy, southern France, and Great Britain. After restoration by Osborn and Knight; 1/50 natural size

races we are now considering, namely, the Brevirostrines, the European and American genera of which are illustrated on p. 15, and the Notorostrines.

To distinguish clearly the sixteen races of proboscideans from one another we must study the back grinders with extreme care, and observe that these grinders are constantly changing their form to compensate for the gains and losses in the anterior grinders and in the upper and lower tusks. Thus, while the external appearance of the Brevirostrines and Notorostrines is not wholly dissimilar, the structure of the back grinders is radically at variance in the two races, and a very tyro in odontography could not fail to distinguish these grinders.

THE BREVIROSTRINES (RACE X).— Very early in their history the Brevirostrines began to lose their lower tusks with the rapid shortening of the lower jaws; in recognition of these changes, one of the first of these fossils found in France was termed '*Mastodon brevirostris*,' or 'short-jawed mastodont.' As in all other proboscideans ,the two compensations were, first, a great increase in size of the upper tusks, which became excessively long and straight in the mastodont of Auvergne, France, and short and massive in the mastodont of Arizona (see figures, p. 15), and, second, a novel and complex mechanism which developed in the back grinders. The first step in this new food-grinding adaptation is seen in the Brevirostrine of Auvergne (*Anancus arvernensis*) and in its distant cousin of India (*Pentalophodon sivalensis*), namely, a twisting of the outer and inner grinding-tooth cones so that they *alternate on the inner and outer sides of the teeth.* Meanwhile in the Indian *Pentalophodon* five ridge crests are added to the teeth in front of the back grinders, and the crowns of the back grinders are heightened. These two new devices in grinding-tooth construction were so successful that these animals increased in numbers in Eurasia and achieved their long journey to North America, where they first appear in western Nebraska, subsequently spreading southward into Texas and Arizona. The veteran palæontologist, Joseph Leidy, was so impressed with the complexity of these Brevirostrine grinding teeth that he thought the animal that bore them worthy of the name *Mastodon mirificus*, signifying the 'wonderful mastodon.' This complexity went on increasing by the addition and complication of the enamel foldings until the crown became a veritable labyrinth of dental tissue, well adapted to the hard grasses and tough woody fiber of the plants then becoming characteristic of the great American desert. It is by this condition of the teeth, ever growing more and more complex, that we trace these animals southward through the species *Stegomastodon* (*Mastodon*) *mirificus* of Nebraska into the *S. texanus* of Texas, thence into the *S. arizonæ* of the ancient playa lakes of Arizona, and finally into the giant *S. aftoniæ* of the First Interglacial epoch of Iowa.

Thus, this long and eventful journey from the Auvergne region of France, and the Norfolk region of England, through India, into the American desert, was rendered possible only by the constant evolution and improvement of the grinding teeth until they attained the highest degree of perfection of their kind.

THE NOTOROSTRINES (RACE IX).— These animals take their name from the Latinized Greek word *Nŏtus*, signifying the south wind, that blew upon them as they left southern California, where their remains have recently been discovered by Mr. Childs Frick, and

journeyed southward along the Andes to the region now known as the Argentine. As discovered in Neogæa, or South America, it was appropriate that Cuvier should name one of these species *Mastodon humboldtii*, in reference to the travels of Alexander von Humboldt, and the other, *Mastodon andium*, commemorating the discovery of remains of this species on the slopes of the Andes.

In these Notorostrines the lower jaws are in process of abbreviation with corresponding loss of the lower incisive tusks, an abbreviation which does not go so fast or so far as in the extremely short-jawed Brevirostrines just described. The superior tusks contain a long ribbon of enamel on the outer side, and as the tusk rotates on its own axis, this enamel ribbon is carried around to the inner side in a corkscrew spiral form, a peculiarity not observed in any other proboscidean. This powerful tusk was so effective that, again following her principle of economy, nature kept the back grinders in a relatively simple condition in the species now known as *Dibelodon* (*Mastodon*) *andium*, In its sister form, *Cuvieronius* (*Mastodon*) *humboldtii*, named in honor of both Cuvier and von Humboldt, the upper tusks are of simpler upturned form, without the enamel ribbon, and the grinding teeth at once become more complex by means of the enamel foldings known as double trefoils.

RACES XII AND XVI, THE LIVING ELEPHANTS, AND RACE XI, THE STEGODONTS

THE LIVING ELEPHANTS (RACES XII AND XVI).—We now turn to the history of the elephant family, Elephantidæ, the second great division of the proboscideans, the two living examples of which are the true elephants of India belonging to the genus *Elephas* of Linnæus, and the elephants of Africa belonging to the genus *Loxodonta* of Cuvier. We know nothing of the direct ancestral history, or of the immediate ancestors, of either *Elephas* or *Loxodonta;* this history still lies buried in the rocks of the great Eurasiatic continent north of India and in the vast unexplored strata of central Africa, but we look forward confidently to the filling in of these missing chapters in proboscidean history. As our knowledge stands at present, the Indian elephant suddenly appears fully formed during the Age of Man and the same is true of the African elephant. Attempts to establish the descent of the Indian or African races either from Race XI (the Stegodonts) or from Races XIII–XV (the Mammoths) will not stand the test of the higher criticism of palæontologists. Yet it appears certain that all the elephants sprang from ancestors like the Stegodonts.

THE STEGODONTS (RACE XI).—From Miocene to Pleistocene time, these very primitive elephants known as Stegodonts were dwellers in the tropical forests, extending from India and the East Indies to China. Differing from the mastodont family, the Stegodonts have a new kind of grinding tooth with multiple ridge crests, from which the grinding teeth of all the higher elephant races may have been derived, and it is not improbable that a certain branch of the Stegodont family wandered into northern Asia and was there transformed into some of the primitive members of the elephant family; such transformation certainly did not occur in southern Asia, where the Stegodonts have their own independent history that culminated in the prodigious and widespread Stegodontines, which left their fossil remains in the same deposits with the earliest of the mammoths. The best-known among these giant Stego-

Living African elephant (*Loxodonta africana* in the forests of Central Africa After photograph by Carl E. Akeley; 1/50 natural size

Courtesy of New York Zoological Society

Living Indian elephant (*Elephas indicus*) and living dwarf Congo elephant (*Loxodonta africana pumilio*) in the New York Zoological Park. After photograph by Elwin R. Sanborn; 1/50 natural size

donts is the species *Stegodon ganesa*, named after one of the legendary deities of India. It is contemporary with a giant true elephant related to the African.

THE THREE RACES OF MAMMOTHS (XIII, XIV, XV) WHICH REACHED AMERICA

The name *Mammut*, probably derived from the Tartar *mama*, signifying earth, in allusion to the discovery of fossilized bones buried in the earth, properly belongs to the northern or woolly mammoth, *Elephas primigenius*, the primordial elephant. The term mammoth is used in the present article in a much broader significance to embrace three great branches of the elephant family. Two of them—the imperial mammoth and the Jeffersonian mammoth,—resemble the woolly mammoth in the architecture of the cranium and in the strong incurvature of the superior tusks, as greatly as they differ from this boreal elephant in the structure of the grinding teeth. The cranium rises into a high acute peak and the forehead is concave instead of being plane and flattened as in the African elephant, or prominent and dome like as in the Indian elephant (see upper and lower figures respectively, p. 18). There are many other features which unite the three races of mammoths among themselves and which separate them from the African and Indian elephants, but the one of paramount interest to us is that these animals were greater wanderers than either the Indian or African elephants and successively entered the American continent as follows:

The imperial mammoth (Race XIII), late in the Age of Mammals, early in the Age of Man.

The Jeffersonian mammoth (Race XIV) during the Age of Man.

The woolly mammoth (Race XV), late in the Age of Man, during the period of the last great glaciation.

THE IMPERIAL MAMMOTH (RACE XIII). This majestic animal was discovered by Ferdinand Hayden, the exploring geologist, in Nebraska, and described by Joseph Leidy in 1858 as *Elephas imperator*, signifying the 'imperial elephant' in reference to the surpassing size of the grinding teeth and the impressive height of the animal. This designation has been more than justified by subsequent discoveries of remains of this gigantic animal in Nebraska, Kansas, Iowa, Texas, California, and Mexico, consisting of portions of teeth, skulls, and skeletons sufficient to establish the fact that the full-grown animals attained a height of 13½ to 14 feet, exceeding by 2½ feet the tallest of the existing African elephants and rivaled only by the gigantic straight-tusked elephant of India and western Europe known as *Loxodonta antiqua*.

The grinding teeth are readily distinguished by their surpassing size and by the relative paucity of the enamel ridge plates, which never exceed twenty in number; the ridge plates are very far apart and the enamel bands are broad, whereas in the woolly mammoth the enamel of the ridge plates is excessively fine, the grinding teeth are relatively small, and the numebr of ridge plates amounts to twenty-seven. It is in reference to this massive but primitive structure of the grinding teeth that Prof. Pohlig has named these animals *Archidiskodon*, signifying primitive ridge plates. The adaptation of these huge, coarse grinders was to tree-and shrub-browsing and the crushing of great masses of leaves and twigs: these imperial mammoths were therefore probably browsers, and with the reduction and disappearance of the western forests, they diminished in numbers and became extinct—the last of a noble line which traces its lineage

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IMPERIAL MAMMOTH (*ARCHIDISKODON IMPERATOR*) OF NEBRASKA AND TEXAS. AFTER RESTORATION BY OSBORN AND KNIGHT; $\frac{1}{50}$ NATURAL SIZE

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WOOLLY MAMMOTH (*MAMMONTEUS PRIMIGENIUS*) OF THE RIVER SOMME, FRANCE, IN LATE GLACIAL TIME. AFTER RESTORATION BY OSBORN AND KNIGHT; 1/50 NATURAL SIZE

back to *Archidiskodon planifrons* in the Upper Pliocene of India and is related to the giant *Archidiskodon meridionalis* of the Pliocene and Lower Pleistocene forests of Italy, France, and Great Britain. In America *Archidiskodon* attained by far its greatest size, as majestically represented in our restoration (p. 20).

THE JEFFERSONIAN MAMMOTH (RACE XIV).—It has taken many years of study to disentangle the lineage of this great immigrant from that of the imperial mammoth on the one hand and that of the woolly mammoth on the other. With the aid of Prof. Hans Pohlig of Bonn and of Prof. Charles Depéret of the University of Lyons this lineage has been traced back to Germany, to southern France, and to Great Britain, and it is now a well established fact that the Jeffersonian mammoth came from smaller and more primitive ancestors which wandered in the forests and meadows of western Europe during the first half of the Age of Man. These European forebears replaced the ancestors of the imperial mammoth and were in turn replaced by great herds of the woolly mammoth that entered Europe in the closing period of the Age of Man. These animals are so distinct from either the imperial or the woolly mammoth stock that we give them the separate generic designation of *Parelephas*, in allusion to their development parallel with the true elephants of India. Whereas the European branch of *Parelephas* became extinct, the American branch flourished exceedingly in the temperate regions of the United States, and its fossil remains are far more numerous than those of either the imperial or the woolly mammoth; *Parelephas* also endured for a long period of time and underwent a considerable evolution in respect to its grinding teeth, from an earlier stage which we have named *Parelephas jeffersonii* in honor of President Jefferson, to a final stage in which the third upper molar possessed as many as thirty plates and the third lower molar twenty-six.

Second only in size to the imperial mammoth, the Jeffersonian mammoth succeeded its imperial forerunner and survived the severe climate of the Fourth Glaciation, at the close of which it became extinct.

THE WOOLLY MAMMOTH (RACE XV).—Late in the Age of Man arrived the woolly mammoth (p. 21), closely related to the *Elephas primigenius* of the ancient steppes and tundras of western Europe. The first to make very close comparison between the west European and the American varieties of this boreal race was Dr. Hugh Falconer, who declared that while the same number of enamel ridge plates was present in the forms of both regions, namely, twenty-four in the last molar of each jaw, the American animals were in general characterized by still finer and more compressed ridge plates than those of western Europe. Thus we may distinguish one of our own forms as *Mammonteus primigenius americanus*, while in Indiana and in Alaska we find a type of mammoth with close-fitting enamel ridge plates to the number of twenty-seven and of such exceeding fineness that we have named it *Mammonteus primigenius compressus*. This adaptation of the grinding teeth for grazing habits was to enable the animal to feed upon the hard grasses which covered the tundras and steppes of the north during the summer season. Thus the woolly mammoth was chiefly a grazer, as proved by the stomach contents of frozen carcasses recovered from the ice in Siberia.

TABLE OF COMPARATIVE HEIGHTS OF CERTAIN ELEPHANTS AND MASTODONTS

Common Name	Scientific Name	Height
Imperial Mammoth	*Archidiskodon imperator*	13 feet 6 inches
African Elephant	*Loxodonta africana*	11 feet 4 inches
Jeffersonian Mammoth	*Parelephas jeffersoni*	10 feet 6 inches
Indian Elephant	*Elephas indicus*	10 feet
American Mastodon	*Mastodon americanus*	9 feet 6 inches
Woolly Mammoth	*Mammonteus primigenius*	9 feet 3 inches
Giant Longirostrine	*Trilophodon giganteus*	7 feet 9 inches
Small Mediterranean Elephant	*Loxodonta (Pilgrimia) mnaidra*	7 feet
Texas Serridentine	*Serridentinus proiectus*	5 feet 8 inches
Small Elephant of Malta	*Loxodonta (Pilgrimia) melitensis*	5 feet
Fayûm Longirostrine	*Phiomia osborni*	4 feet 5 inches
Young Congo Elephant	*Loxondonta africana pumilio*	4 feet 5 inches
Smallest Elephant of Malta	*Loxodonta (Pilgrimia) falconeri*	3 feet
Fayûm Mœrithere	*Mœritherium andrewsi*	2 feet 1 inch

The woolly mammoth is relatively diminutive in size, not much exceeding nine feet and, despite the grazing adaptation in its grinding teeth, it shows its relationship both to the imperial and the Jeffersonian mammoths in two outstanding characters, namely, the extreme acuteness of the apex of the skull and the strong incurvature of the tusks, which completely cross each other in old age and no longer serve either for purposes of combat or for the gathering of food. Remains of the woolly mammoth are relatively rare in the United States but a few fine skulls have been recovered from Indiana and from Alaska, in which the acute apex, the concave forhead, the extreme flattening and deepening of the cranium and the tooth sockets may be observed.

We know little of the external appearance of the imperial mammoth; it was probably nearly hairless like the Indian and the African elephants. The Jeffersonian mammoth, we believe, was partly hairy, for it is characteristic of the north temperate region both of Europe and the United States. The northern mammoth of the Ice Age was both hairy and woolly and was perfectly adapted to the extremely severe climate of the Arctic Circle and of the borders of the advancing ice sheets. Both in their immense geographic range and in their extremes of adaptation to different climatic zones, these three branches of the mammoth family rank as the *facile princeps* among the mammals which ruled the Northern Hemisphere during the Age of Man.

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Stegomastodon arriving in Arizona. After restoration by Osborn and Knight

Mastodons of the Hudson Highlands

By HENRY FAIRFIELD OSBORN
President of The American Museum of Natural History

One of the greatest treasures of the American Museum is the unrivaled skeleton of the fossil proboscidean known as the WARREN MASTODON. The present article gives the fullest and most authentic history of this specimen which has ever been published, thanks to the testimony of several eyewitnesses who have kindly written to the author, and to others.

THE WARREN MASTODON, found in 1845, was the fifth in a series of discoveries of mastodon skeletons, beginning with Peale's first skeleton of 1799, which like the WARREN MASTODON was found in Orange County, New York. The first reference to mastodons along the Hudson was, however, as early as 1705.

The following table relative to early discoveries of the mastodon has been compiled from *The Mastodon Giganteus of North America*, which Dr. John Collins Warren published in 1852:

1705.—First mention of finding mastodon remains near Albany.

1714.—First published account of two teeth and a thigh bone found at Claverack, on the Hudson, thirty miles south of Albany.

1799–1801.—Peale's first skeleton, found on John Masten's farm, Orange County, New York. See Warren, Plate I, upper left-hand figure. Exhibited in London; in Peale's Museum, Philadelphia; and then disappeared.

1802.—Peale's second skeleton, "Baltimore Skeleton," purchased by Doctor Warren in 1848, dismantled. A very large jaw, described by Doctor Warren. See Warren, Plate I, upper right-hand figure.

1840–43.—Koch's "Missourium," a composite of several specimens found near Kimmswick, Missouri. Remounted by Richard Owen, in the British Museum. See Warren, Plate I, lower right-hand figure.

1844–45.—"Cambridge mastodon," found near Hackettstown, Warren County, New Jersey, twenty miles from Newark. See Warren, Plate I, lower left-hand figure.

1844.—"Shawangunk Skull," found near Scotchtown, Orange County, New York; now in the American Museum, Warren Collection.

1845.—The WARREN MASTODON in the American Museum, found on the Brewster Farm, Orange County, New York. See Warren Memoir, Vignette; also Plate I, center figure; also Plates IV to XXV.

In *An Outline History of Orange Co.*, by Samuel W. Eager, published in 1846–47, only a year after the discovery of the Warren Mastodon, is found the following quaint narrative of the succession of discoveries in Orange County, and an interesting reflection of the scientific opinions of the middle of the nineteenth century.

"We cannot, without disrespect to the memory of a lost but giant race, and slighting the widespread reputation of old Orange as the mother of the most perfect and magnificent specimens of terrestrial animals, omit to tell of the mastodon. Contemplating his remains as exhumed from their resting place for unknown ages, we instinctively think of his great and lordly mastery over the beasts—of his majestic tread as he strode these valleys and hill-tops—of his anger when excited to fury—stamping the earth till trembling beneath his feet—snuffing the wind with disdain, and uttering his wrath in tones of

EXCAVATION OF THE PEALE MASTODON

In 1799 there was discovered on the farm of John Masten, near Newburg, New York, the skeleton known as Peale's first mastodon. The exhumation of this skeleton, portrayed in the painting, was carried on in the year 1801. The principal figure in the foreground is Dr. Charles Willson Peale. The other two figures assisting him in holding the scroll are probably Titian and Rembrandt Peale.

This photograph shows at work twenty-one men and two boys of the twenty-six who were engaged under the direction of Doctor Peale. The elaborate machinery that occupies the center of the picture consists of a continuous bucket chain with a long trough. It was designed by an ingenious millwright to keep the excavation free of water. A number of the male onlookers and even some of the workmen wear tall beaver hats as part of the quaint dress of the period. The whole scene, painted after the manner of other scientific portraits of the day, is a delightful reminiscence of the country life along the Hudson one hundred twenty years ago.

(After photograph of the painting by Rembrandt Peale, belonging to Mrs. Bertha White, now deposited in the American Museum of Natural History.

thunder,—and the mind quails beneath the oppressive grandeur of the thought, and we feel as if driven along by the violence of a tornado. When the pressure of contemplation has subsided and we recover from the blast, we move along and ponder on the time when the mastodon lived,—when and how he died, and the nature of the catastrophe that extinguished the race; and the mind again becomes bewildered and lost in the uncertainty of the cause. Speculation is at fault, and our thoughts wander about among the possible accidents and physical agents which might have worked the sudden or lingering death of this line of terrestrial monarchs.

"Upon these subjects, wrapt in the deep mystery of many ages, we have no fixed or well-considered theory; and if we had, the limits of our paper would forbid us to argue it up before our readers, and argue down all hostile ones. But we may briefly enquire, whether the cause of the death and utter annihilation of the race, was one great overwhelming flood which submerged the earth and swept down these animals as they peacefully and unsuspiciously wandered over the plains and hills around us. Or was it some earthquake convulsion, full of sudden wrath, which tore up its strong foundations and buried this race among the uplifted and subsiding mass of ruins; or was it some unusual storm, black with fury and terrible as the tornado, which swept the wide borders of these grounds, and carried tree and rock and living mastodon in one unbroken stream to a common grave, or was it the common fate of nations, men and every race of created animals of water, land or air, which overtook and laid the giants low? that by the physical law of their nature, the decree of heaven, the race started into being—grew up to physical perfection—and having fulfilled the purpose assigned by their creation, by a decrease slow, but sure as their increase, degenerated in number, and gradually died away and became extinct. Or was it some malignant distemper, fatal as the Egyptian murrain, which attacked the herd in every locality of this wide domain—sending its burning poison to their very vitals—forcing them to allay an insatiate thirst and seek relief in the water ponds around them, and there drank, and drank, and died? Or was it rather, as is the general belief in this community, that individual accident, numerous as the race, befell each one, and in the throes of extrication sank deep and deeper still in the soft and miry beds whefe we now find their bones reposing?

"We have thus briefly laid before our readers all the causes which we have heard assigned for this remarkable, ancient, and wide-spread catastrophe, and leave them to the speculation of others, while we wait for time and the developments of geology to uncover the cause.

"But when did these animals live and when did they perish, are questions equally wrapt in profound mystery, and can be answered only when the true cause of their death is found. In the meantime we ask, were they pre-Adamites, and did they graze upon the fields of Orange and bask in the sunlight of that early period of the globe?—or were they antediluvian, and carried to a common grave by the deluge of the Scriptures?—or were they postdiluvian only, and till very recent periods wandered over our hills and fed in these valleys; and that now some wandering lord of the race, an exile from the land of his birth on the banks of the great father of waters, is gone in silence and melancholy grandeur to lay himself down and die in the yet unexplored regions of the continent? On the points of vital interest in solving the great question of time and mode of death, we hazard no conjecture. Among geologists the opinion is fast gaining ground, that the epoch of the appearance of the mastodon on earth was about the middle of the tertiary period,—and that he was here ages before man was created,—that before that epoch warm-blooded terrestrial animals had not appeared. The period of their extinction is thought to be more doubtful, but probably was just before the creation of the human race.—Geologists think there is no evidence sufficient to establish the fact that man

and the mastodon were contemporary. —Time and further investigation may explain the mystery.[1]

WHEN FIRST FOUND

"The remains of the mastodon were first found in this State, near Albany, probably as early as 1705, as appears from the letter of Gov. Dudley to the Rev. Cotton Mather, of July 10, 1706—a copy of which is furnished and worth reading.[2] The accounts which state it to have been in 1712 are erroneous—taking, probably the date of Cotton Mather's letter (of that date) upon this subject to Dr. Woodward, as the date of the finding. They were next found by Longueil, a French officer, on the Ohio River, in 1739. In 1740 large quantities were found at Big Bone Lick, in Kentucky, carried to France and there called the "Animal of the Ohio." Since which many have been found in various parts of the Union.

"No locality,[3] except the Big Bone Lick, has contained a greater number of these remains than Orange County. The first were discovered in 1782, about three miles south of the village of Montgomery, on the farm now owned by Mr. Foster Smith. These bones were visited by Gen. Washington and other officers of the army while encamped at Newburgh in 1782–3. The Rev. Robert Annan, who then owned the farm, made a publication at the time, describing the bones, locality, etc., which caused Mr. Peale subsequently to visit this county.

"In 1794 they were found about five miles west of the village of Montgomery, just east of the residence of Archibald Crawford, Esq., and near the line of the Cochecton turnpike. In 1800 they were found about seven miles northeast from Montgomery, on or near the farm of Dr. George Graham. In 1803, found one mile east of Montgomery, on the farm now owned by Dr. Charles Fowler. These were the bones dug out by Mr. Peale of Philadelphia, in 1805 or 6,—and the writer, then a boy at school in the village, saw the work in progress from day to day. In 1838 a tooth was found by Mr. Daniel Embler, of Newburgh, on or near the farm of Samuel Dixon, Esq., of that town. In 1844, found eight miles southwest from Montgomery, on the farm of Mr. Conner, near Scotchtown, in Wallkill. In 1845, found about seven miles east of Montgomery, on the farm of Nathaniel Brewster, Esq.; and, in the same year, on the farm of Jesse C. Cleve, Esq., in Hamptonburgh, about twelve miles southeast of Montgomery. They were also found in the town of Goshen some years since, but the time and locality we do not know. There have been at least a dozen findings of these bones in the County. From these enumerations it would appear as if the village of Montgomery was the center of the circle of these various findings

. . . . . .

"The animal [the skeleton found on the farm of Nathaniel Brewster and subsequently known as the Warren Mastodon] was supposed to be of great age—judging from the length and size of the tusks, and from the fact that some bones, which in young animals are separate, in this had grown firmly together.

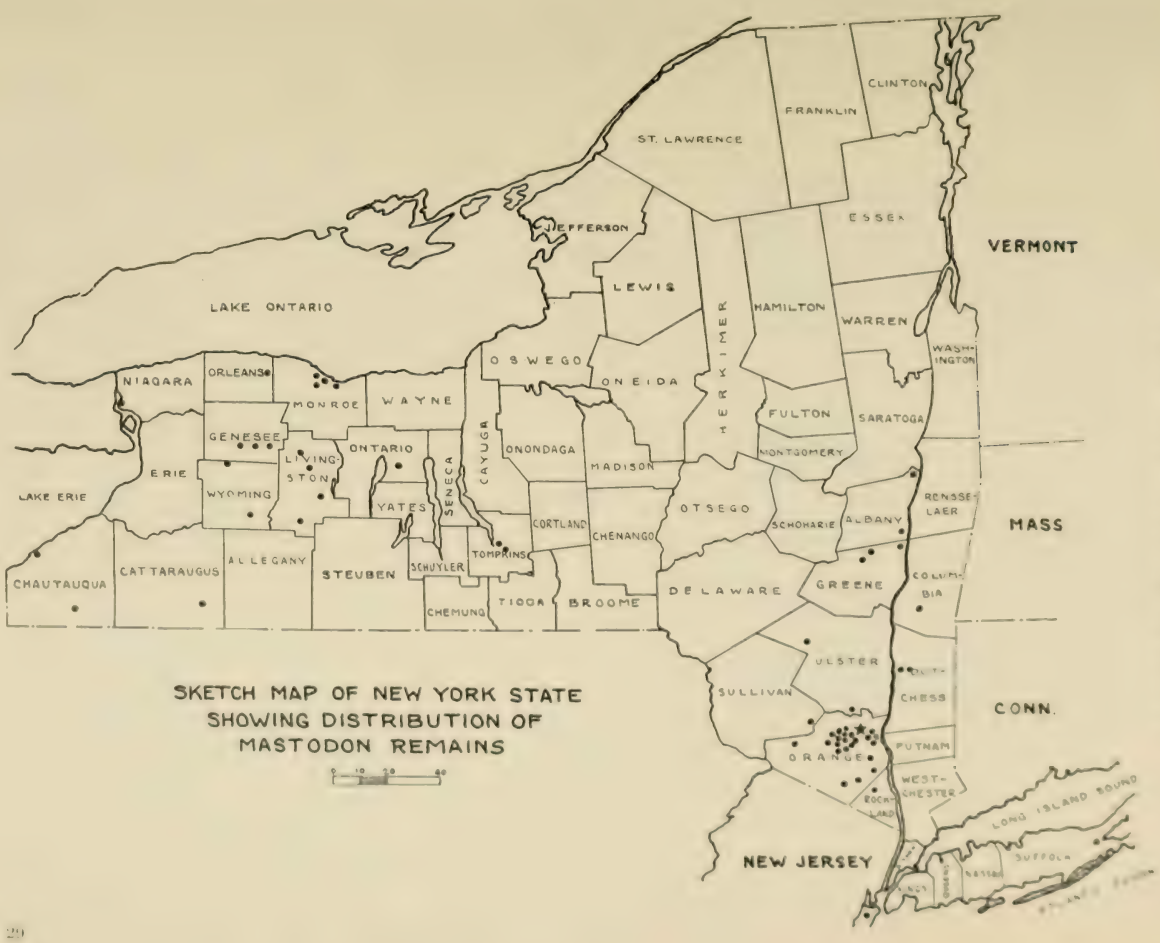
POSITION OF THE BONES WHEN FOUND

"Having measured the giant, let us inspect the place where found, uncover his resting place and observe his position in death. Mr. Brewster was digging out marl, and his workmen came upon the skeleton, every bone of which they succeeded in exhuming. Though wanting some of the toes of the forefoot, we believe they were found and carried away in the pockets of some of the early visitors. Like all others in this County, these were found in a peat formation, but of very limited extent, between two slate ridges. They were six feet beneath the surface —yet so deep was the peat below that its bottom could not be reached with an iron rod of several feet in length. The animal was thus held in suspension, and as the spot was wet and spongy, never dry perhaps from the

[1]The reader is referred to an article entitled "Did the Indian Know the Mastodon?" by Jay L. B. Taylor, NATURAL HISTORY, 1921, pp. 591–97; also to the article by William B. Scott "On American Elephant Myths," *Scribner's Magazine*, 1887, p. 469.

[2]This letter is not reproduced in the present article.

[3]Remains indicating 300 animals were found at Kimmswick, Missouri.



DISCOVERY SITES OF MASTODONS IN NEW YORK

This map, taken from that which appears in the article entitled "Mastodons of New York," by Dr. John M. Clarke (New York State Museum, *Bulletin 69*, published 1903) shows, by the concentration of the dots just north of the Hudson River Highlands in Orange County, how numerous are the mastodon remains in that area. The site where the Warren Mastodon was discovered—formerly known as the Nathaniel Brewster Farm but now called the Sycamore Farm—is indicated on the map by a star

The Warren Mastodon was discovered on the site marked by the star, in the valley south of Orange Lake and about two hundred yards north of the Cochecton Highway at East Coldenham. The skeleton was at first known as the Brewster Mastodon because of the fact that the farm on which the find was made was the property of one Nathaniel Brewster, a grandson and namesake of whom is now the owner of the land. Reproduced from the Newburg Quadrangle Topographical Survey, State of New York, United States Geological Survey, edition of September, 1903, reprinted September, 1910

time he entered, it caused their perfect preservation.

"Beginning at the bottom, the following were deposits which from time to time filled up the pond:

1, Mud, more than ten feet,
2, Shell Marl, three feet,
3, Red Moss, one foot,
4, Peat, two feet.

The bones laid below No. 3 and occupied nearly the position the animal did when alive, and the whole position that of one mired. If there ever was one that came to his death in that way, this is the one.

. . . . . .

"In Godman's Natural History, article Mastodon, is recorded an instance of the same kind [the preservation of stomach contents], and puts the fact beyond all question, that the contents of the stomach of the Brewster [Warren] mastodon were found. The animal was dug up in Wythe Co., Va., and the stomach found,—the contents carefully examined, and found to be in good preservation. They consisted of reeds half masticated—of twigs of trees, and of grass or leaves.

We have made free use of the article written by Dr. A. J. Prime, of Newburg, and found in the American Quarterly Journal of October, 1845, and various newspaper publications made by the same gentleman."

Thus ends our quotation of the quaint narrative of Samuel W. Eager.

OTHER REMINISCENCES OF THE DISCOVERY

The American Museum is indebted to Mrs. George F. Elliott of Westfield, New Jersey, for the following reminiscence of the discovery, contained in a letter of March 21, 1906, addressed to the late J. Pierpont Morgan, the donor of the Warren collection to the American Museum Mrs. Elliott, writes:

"I was much interested on reading in this morning's *Tribune* of your recent purchase of the American mastodon from the Warren heirs; interested firstly, because it will now be given to the public; secondly, because it was found on, or in, my grandfather's farm in East Coldenham, six miles west of Newburgh, on the Newburgh and Cochecton turnpike. As a child I distinctly remember the excitement that prevailed in the neighborhood at the find and during the time it was on exhibition in my grandfather's barn. It was wired and set up on the premises. Doctors Warren, Hitchcock, Blackman, and Prof. Silliman were all there at times. The location where it was found was in a depression or sort of basin of marl, which they were taking out for improving the land elsewhere. The head was struck first, for the animal was standing erect, as it had sunk in the soft marsh. Even the contents of the stomach were intact, consisting of twigs as large as a

I was present at
the original discovery
of the Warren Mastodon
discovered in 1845
and assisted in the
Exhibition of same

J. V. Cromwell
M. D. Cain
Mich

Sept 2nd 1907

THE WARREN MASTODON IN SITU

Vignette showing the Warren Mastodon as it was stretched out when originally discovered about six miles northwest of Newburg and about one mile south of Orange Lake. The vignette, which appeared originally in color on the title page of Doctor Warren's *Mastodon Giganteus of North America*, is designed to show the succession of strata under which were found the skeletal remains. Usually all these strata were covered during the wet season with a depth of water varying from one or two feet to six or eight feet, but during the unusually dry season of 1845, the year of the discovery of the skeleton, the area had almost dried up. According to Doctor Warren, the position of the extremities shows that the animal, at the time of its destruction, was making strong efforts to extricate itself from the abyss into which it had plunged. Beneath the body and limbs is a stratum of clay but the body was embedded in light-colored shell-marl, which incased the head, the right anterior limb, spinal column, part of the ribs, pelvis, and the tail. Above the shell-marl was a layer of red moss of a pinkish color; the top layer was of dark-colored peat a foot or two in thickness; above this in ordinary seasons was the depth of water already referred to

On Saturday, August 19, 1922, the writer visited the locality where the Warren Mastodon was discovered and had the good fortune to meet Mr. Nathaniel Brewster, the grandson of the original owner and excavator of the skeleton, who with his daughter, Miss Brewster, gave the writer a most courteous reception.

Mr. Brewster pointed out the original boxes, excellently constructed, in which the skeleton was originally packed and transported from place to place for exhibition. Although a small boy at the time, being only three years of age, he distinctly recalls placing his little fist in the eye socket of the mastodon skeleton. He also recalls the spot where the mastodon was found, now buried beneath a pond of considerable size. On September 6, 1922, Mr. S. H. Chubb visited the site with his excellent camera and photographed Mr. Brewster pointing to the spot in question (see lower picture; the upper picture shows another view of the same locality). The relation of the site to its envoirnment is shown in the map on p. 8.

man's finger, and were gathered in a bushel basket. The tusks were also perfect when found, but crumbled on coming in contact with the air. There is a brooch in the family with the head in 'profile' of one of my uncles carved on it, made from a piece of the outside of these tusks; there is also a part of a tooth that broke off after it was set up. My oldest brother, who now occupies the homestead, has much interesting data in connection with it, also an engraving of the different strata of soil in which it was found, with a cut of each separate bone, and would furnish you, no doubt, with anything of interest to you in connection with it. It was sold to Doctor Warren by my father while he had it on exhibition either in Hartford of in New Haven."

Another reminiscence is that contained in a letter received at the American Museum on August 16, 1907, from Mr. W. M. Nelson of Equinunk, Wayne County, Pennsylvania, who writes:

"So far as I know, I am the only living man today[1] who saw the skeleton of the animal taken from the marl pit on the farm of Nathaniel Brewster, six miles west of now Newburgh City, where the road runs north to Orange Lake. I saw the entire skeleton taken out and bones wired together by Doctor Prime, of Newburgh, in Mr. Brewster's barn. This was done in sections so it could be set up and taken down and shipped in the boxes as freight. It was on exhibition about the country by Wm. Brewster and Clinton Weeks, son and son-in-law of Mr. Brewster.

"Squire Eager's history of Orange Co., New York, gives the dimensions of the skeleton as follows: length of skeleton 33 feet; skull between eyes 2 feet, 1 inch; length of skull 3 feet, 10 inches; number of bones 220; ribs, 20 on each side. Total weight of bones, 1995 pounds. . . . The mastodon's backbone was found about 5 feet below the surface in the marl pit. Every bone was found and wired, except one toe bone, about the size of an egg. I was a boy some 16 or 18 years old at the time and took it all in. I remember nothing about Professor Warren. Doctor Prime wired the bones together and I saw him most every day at the work of setting up the skeleton. I do not know whether this history is of any interest to you now, but it will hold water, so far as my memory is concerned."

The above reminiscences may be supplemented with the account of the discovery gathered from the memoir by Doctor Warren published in 1852:

"The summer of 1845 had been unusually dry; many small lacustrine deposits were exposed by the drought, and their contents removed to fertilize the neighboring fields. The spot above described, though usually covered by a small quantity of water, had been left dry (an occurrence never known before); and Mr. Brewster, wishing to avail himself of its contents, had employed a number of laborers to remove them. The men had dug through a thickness of two feet of peat-bog, a layer of red moss about a foot thick, and then fell upon a bed of shell marl (*vide* Vignette).[1] After raising about a foot of this, they struck on something hard; and a question arose whether it was a rock, a bone, or some other substance. Night approaching, it was necessary to intermit their labor until the following day.

"Mr. William C. Brewster, son of the proprietor, and Mr. Weeks, his son-in-law, with assistants, in the presence of a large number of persons, neighbors, and travellers, proceeded to examine the object of their curiosity. The stroke of a spade brought up a portion of bone, and everyone was then willing to believe they had discovered the last retreat of one of the ancient mastodon inhabitants. The labor of exhumation then proceeded rapidly; and the part struck was ascertained to have been the summit of the head. This, being uncovered, disclosed to the eyes of the spectators the full extent of the cranium, which was four feet in length.

[1]Another survivor is Mr. Nathaniel Brewster, a grandson of the owner of the farm at the time of the discovery, who is shown on p. 33 pointing to the spot from which the skeleton was recovered.

[1]The vignette is reproduced on p. 32 of the present article.

The lower jaw was distorted a little toward the left side. The bones of the spine, tail, pelvis, and ribs, were successively found, for the most part in their natural relation to each other. The anterior extremities were extended under and in front of the head, as if the animal had stretched out its arms in a forward direction to extricate itself from a morass, into which it had sunk. The posterior extremities were extended forward under the body. The tusks lay with their convexities outwards, their anterior extremities opposed to each other nearly meeting; and thus the two tusks, taken together, described a large part of a circle. (*Vide* Vignette.)

"At the end of the second day's labor, the whole of the skeleton had been obtained, with the exception of the posterior part of the sternum, a few bones of the feet, and a number of the caudal vertebræ, some of which were recovered afterwards. The bones were in an almost perfect state of preservation. They were not black, like most of the mastodon bones, but of a brown color, like those of a recent human skeleton, which had been in use a considerable time. It is worthy of remark, that no mastodon bones but those belonging to this individual, and no other bones excepting two or three of animals recently entrapped in the mire, were found in this deposit."[1]

. . . . . .

"Doctor Prime, who was present, describes its appearance as follows:—'In the midst of the ribs, embedded in the marl and unmixed with shells or carbonate of lime, was a mass of matter, composed principally of the twigs of trees broken into pieces of about two inches in length, and varying in size from very small twigs to half an inch in diameter. There was mixed with these a large quantity of finer vegetable substance, like finely divided leaves; the whole amounting to from four to six bushels. From the appearance of this, and its situation, it was supposed to be the contents of the stomach; and this opinion was confirmed on removing the pelvis, underneath which, in the direction of the last of the intestines, was a train of the same material, about three feet in length or four inches in diameter.'"[1]

[1] *The Mastodon Giganteus of North America*, by Dr. John C. Warren, pp. 5 and 6.

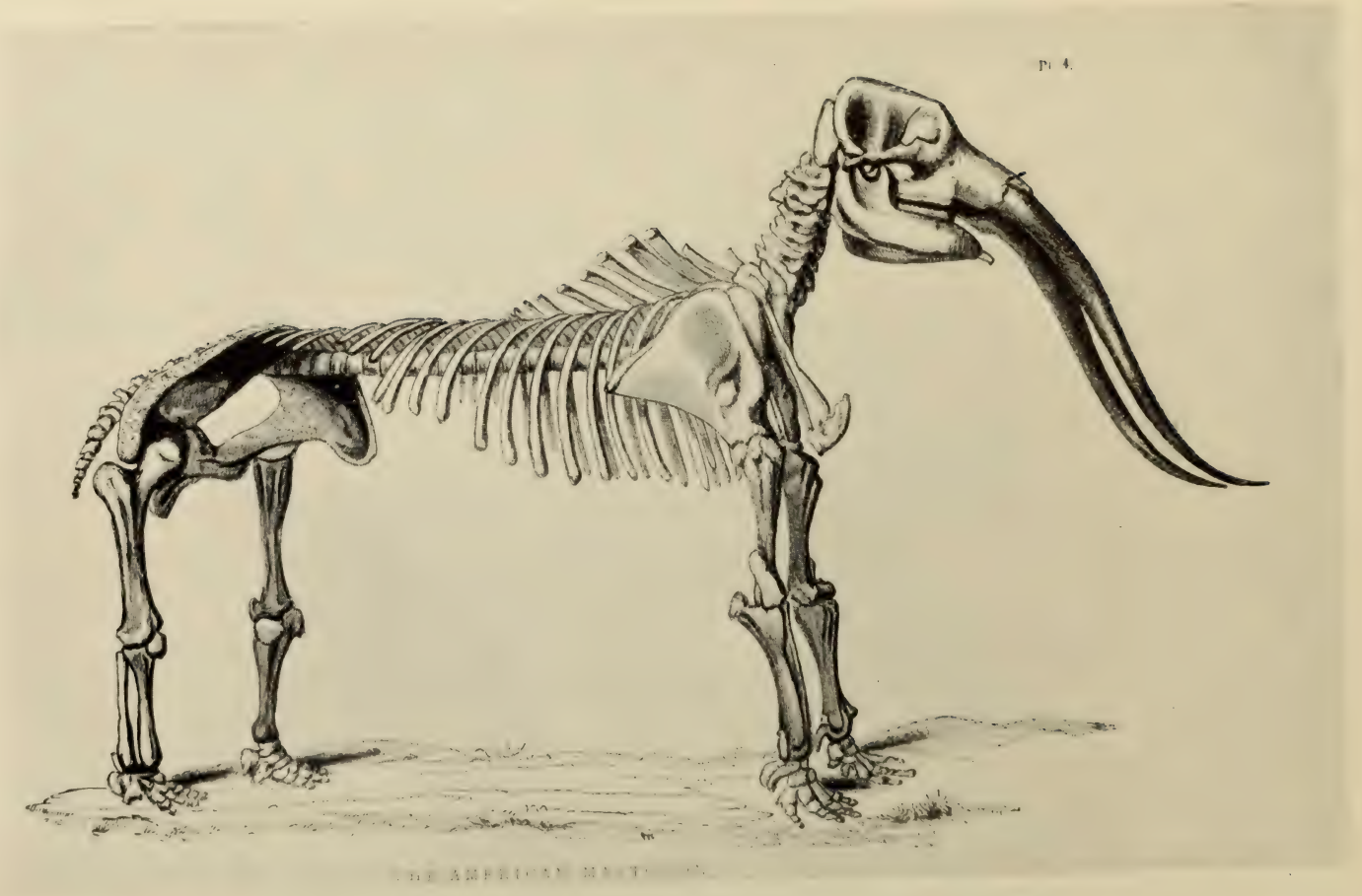
TOUR OF EXHIBITION

Owing to the fact that the bones were buried in a pure shell-marl layer, they were, when found, in a perfect state of preservation; of light brown tint, not of the dark brown or nearly black tint of the mastodon skeletons exhumed from swamp muck, which are discolored by decaying vegetable matter. As narrated by two eyewitnesses, the skeleton was wired together and set up in such form that it could be exhibited for three or four months during the years 1845 and 1846, in the city of New York and in several New York and New England towns. Luckily, it does not appear that any of the parts were lost during this period of exhibition and travel.

The excellently made boxes in which the skeleton of the Warren Mastodon was transported from point to point for exhibition still remain in the possession of Mr. Nathaniel Brewster, The impression which the mastodon made on observers in the city of New York is shown by an extract from the journal of one of the pupils of the New York Institute for the Deaf and Dumb, October 16, 1845:

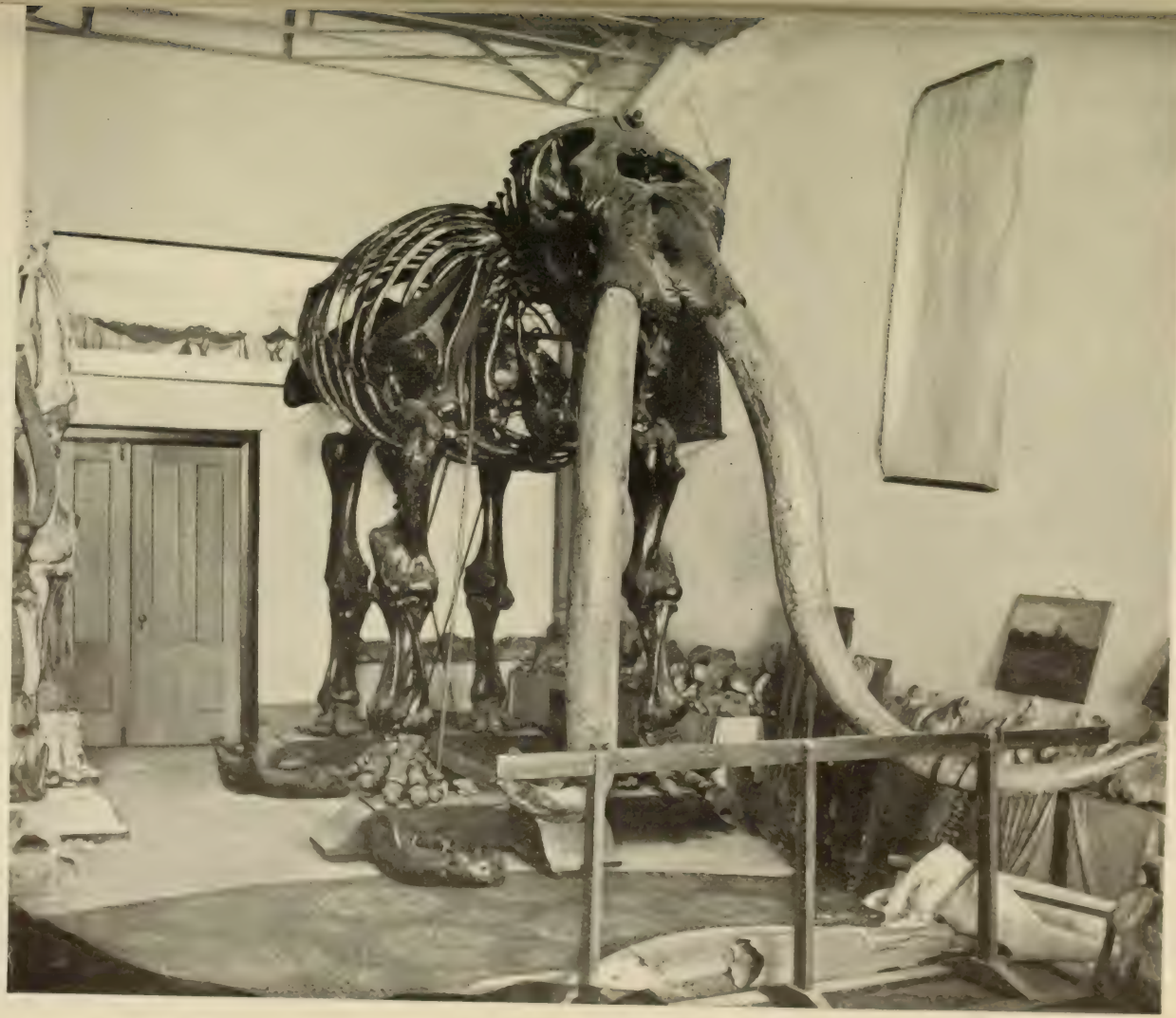
"Having been kindly invited by the proprietors of this wonderful exhibition, we went up into the Minerva Rooms, 406 Broadway, and looked at the American Mastodon, one of the greatest curiosities in the world, according to my imagination. We steadily gazed at it with much astonishment. The bones of it are articulated together or fastened to each other by iron nails so as to form a skeleton, and it is now exhibited in this city. Two long artificial tusks measuring ten and a half feet in length are fixed into the

[1] *Idem.*, p. 144.



THE WARREN MASTODON AS IT WAS MOUNTED SHORTLY AFTER ITS DISCOVERY

The figure is reproduced from the *American Journal of Agriculture and Science*, Volume II, Number 2, conducted by E. Emmons, Albany, and A. J. Prime, Newburg In their article, "The Great American Mastodon," Messrs. Emmons and Prime remark: "The skeleton has since been arranged and set up, and this has been done with great care and the strictest attention to the articulating surfaces of all the bones, which we believe has not been the case with others which have been put together"



THE WARREN MASTODON AS REMOUNTED IN 1849

For fifty-seven years, that is from 1849–1906, the Warren Mastodon, remounted as shown in the picture, was exhibited in the Warren Museum in Boston. In 1906 it was acquired, thanks to the generosity of the late J. Pierpont Morgan, by the American Museum.

The skeleton, as here depicted, is covered with heavy black varnish. The imitation tusks are made of papier-maché and were so lengthened as to sweep the ground and curve outwards at the extremities. The chest and backbone were raised two feet above the top of the shoulder blade, or scapula, and as a result the natural height of the animal was increased from nine feet to twelve feet. Beneath the Warren Mastodon are tusks and grinding teeth of other specimens. Around the base of the walls are many vertebræ of the giant *Zeuglodon*, the archaic fossil whale of southern United States.

As photographed in the interior of the Warren Museum, 92 Chestnut Street, Boston

skull; the old tusks of nature are almost corrupted, and it is said that they were found entire in the skull when first discovered, but they have fallen in pieces so that they cannot be made fast. The large vertebræ of its spine or backbone gradually increase in size from the extremity of the tail to the head. We could stand below the long ribs. We examined the legs and bony toes with great curiosity. The whole bones weigh 2002 pounds but they must have weighed 20,000 pounds when it was living. The skeleton measures 29 feet in length, and the height of its head, 12 feet, that of its back, 10 feet, and the width of the pelvis, 6 feet.

"The skeleton, which has been brought to this city for a show, was found in a marl bed on a farm at New burgh, of New York. I am very proud of that skeleton first discovered in this state.

"It is supposed that this animal on walking along the marl bed, sunk into it by its legs adhering closely to the marl and it was drowned. It remained in it for a long time. Previous to the discovery, nobody knew the place where it was buried. We should be thankful to the proprietors who found it and took great pains to fix the bones firmly into a skeleton. What a wonderful success!! It leads us to admire the power and wisdom of our Almighty Maker who made the largest of animals."

DOCTOR WARREN ACQUIRES THE MASTODON

Fortunate was its purchase in 1846 by Dr. John Collins Warren, professor of anatomy in the Harvard Medical School, who paid $5000 for it. Doctor Warren, who about this time became president of the Boston Society of Natural History, had the skeleton transferred to Boston, where it was mounted under his direction by Dr. N. B. Shurtleff; this was its second mounting. It was exhibited to Sir Charles Lyell, the distinguished English geologist, who made a tour of the United States during the years 1841–45; also to Professor Jeffries Wyman, founder of the Museum of Comparative Anatomy, Harvard Medical School; also to Professor Louis Agassiz, who was called to Harvard University in the year 1848.

The teeth of the mastodon had been known in America since 1705 and in Europe ever since Longueil, a French officer, brought them back from the banks of the Ohio River in 1739; they had been examined and described by the great French naturalist of the period, Buffon; they had been assigned the specific name of *Elephas americanus* by the American naturalist, Kerr, in1 792; they had been falsely confused with those of the woolly mammoth of Siberia by Blumenbach, who gave this animal the name of *Mammut;* they had finally, in 1806, been properly christened 'mastodonte' by the great French naturalist, Cuvier; yet the actual structure and proportions of the mastodon still remained unknown. Consequently the discovery and mounting of the Warren Mastodon skeleton was a really great event in the science of palæontology; it rendered possible for the first time a knowledge of the complete animal. It appears, however, that Doctor Warren was not satisfied with the mounting by Doctor Shurtleff, nor with the security of the building where the skeleton was first exhibited in Boston, because in 1849 the mastodon was remounted by Mr. Ogden under Doctor Warren's direction and placed with other collections in the especially erected fireproof building at 92 Chestnut Street, Boston, which soon became famous as the Warren Museum. It was at this time that the skeleton received its coat of black varnish, was raised two feet above its natural height, and was provided with the enormous pair of papier-maché tusks.

From 1849 to 1906 the skeleton remained in the Warren Museum in the

condition shown in our photograph on page 15. Professor Warren became intensely interested in adding to his museum other specimens of the mastodon, especially those discovered along the west bank of the Hudson River, and also in securing specimens from England, France, and Germany, for purposes of comparison. Thus his collection was enriched by the acquisition of the superb head of an old bull mastodon found near the Shawangunk Mountains, and hence known as the Shawangunk head; this is one of the largest, if not the largest, bull mastodon head ever found. Through active correspondence with Professor Jean Jacques Kaup, Doctor Warren secured casts of all the specimens that Professor Kaup had discovered near Eppelsheim not far from Worms in Germany, namely, *Mastodon longirostris* (signifying long-jawed mastodon) and *Dinotherium giganteum* (signifying the terrifying giant beast), animals which at the time aroused the wonder of Europe. Thus there were soon gathered in the Warren Museum numerous specimens from different parts of the world—North America, Europe, and Asia—bearing on the history of the proboscidean order. Doctor Warren devoted his spare time for six years to the study of these animals, and in 1852 issued a splendid monograph entitled *The Mastodon Giganteus of North America*. In April, 1908, the autograph copy of this precious publication, with marginal annotations in Doctor Warren's handwriting, was presented to the Osborn Library of the American Museum, together with *The Life of John Collins Warren, M.D.*, in two volumes, by Dr. Edward Warren.

REMOVAL TO THE AMERICAN MUSEUM

The writer of the present article had for years longed to secure this famous specimen for the American Museum but never dreamed that it would be possible to obtain it. It appeared that the entire Warren collection was entailed in the will of Doctor Warren and that the heirs were not at liberty to dispose of it until the decease of the last of the immediate descendants. The writer was greatly surprised, therefore, when he received a letter from Dr. Thomas Dwight of the faculty of the Harvard Medical School, indicating that the entail was at last closed and that the collection might be offered for sale under certain conditions. This letter came on a Friday afternoon and the writer left the same evening for Boston, arriving in Doctor Dwight's study on Saturday morning; he accompanied this distinguished anatomist to the old Warren Museum on Chestnut Street to view the famous skeleton for the first time. The black varnish appeared to present an obstacle, but some vigorous scratching with a penknife revealed the rich light-brown color of the bone beneath. A friendly interchange of opinions with Doctor Dwight ensued; a valuation was agreed upon for the entire collection, but there was still little thought in the writer's mind that it could be secured by the American Museum. On the Monday following, the prince of museum benefactors, Mr. J. Pierpont Morgan, authorized by telephone an offer of $30,000. This offer was immediately accepted and a few days later Dr. William Diller Matthew went to Boston to pack up the entire Warren collection, covered as it was with a half century of Boston dust. The collection was carefully inventoried, and with it came several valuable photographs and pictures, which are reproduced in the present article.

THE FOURTH MOUNTING OF THE WARREN MASTODON

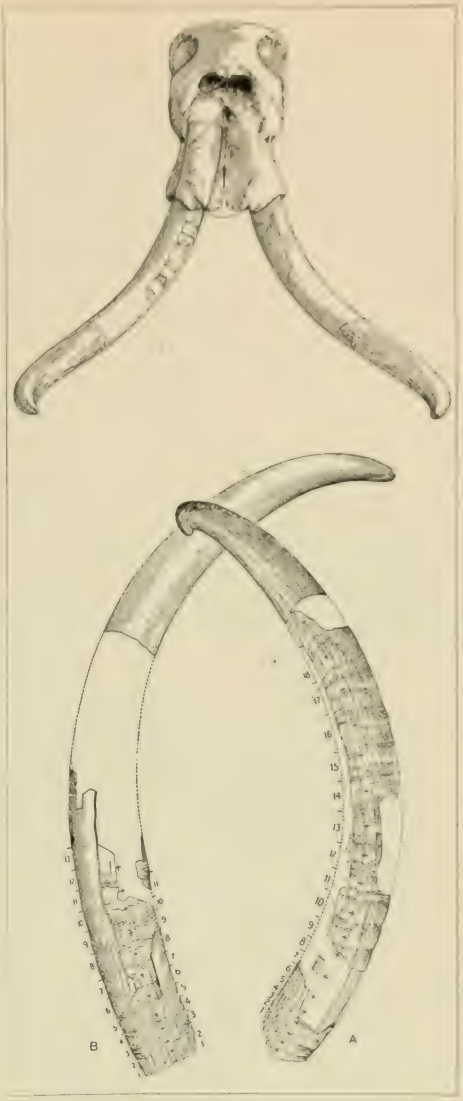
In removal all the original framework was left in Boston, only the bones being packed; in this separated condition the precious skeleton, covered with its thick coat of black varnish, reached New York, its native State, in safety. The first question which arose in our minds was whether it would be possible to remove the black varnish; this was answered through a series of experiments which resulted in the construction of special vats large enough to contain the longest and broadest bones, such as the thigh bones, the hip girdle, and the skull. Many weeks of immersion in pure benzine were necessary before the black varnish began to dissolve. This treatment was followed by vigorous scrubbing with pure spirits of alcohol, and one by one the bones emerged from this prolonged and very expensive bath in all the purity and beauty of color that characterized the skeleton when it was exhumed by Doctor Prime in 1845.

There still remained the problem of the tusks, which are invariably the most vital part of buried skeletons of the great proboscideans of the past. It appears that the original tusks could not be preserved entire by the methods then known. The discoverers were unable to prevent them from splitting, warping, and falling to pieces, especially at the butt. In order to preserve what could be saved intact, the butts of the tusks, already hopelessly split and warped, were sawed off under Doctor Warren's direction, and only the tips, about three feet in length, were treated and preserved. The butts, fallen into fragments, but still lying undisturbed in two of the original boxes used for transporting the skeleton, were found in the Warren Museum when the skeleton was repacked to be sent to the American Museum. The tips, treated with preservatives, were still intact in another box; but neither had been used apparently for measurements in making the papier-maché restorations fitted to the skull in the Warren Museum. This documentary evidence certainly was not used by Professor Warren, because in his three restorations he unfortunately accepted the erroneous original reports that the tusks as found were more than eleven feet in length; they were so described and illustrated by him in the entirely impossible position shown in the photograph on p. 37.

When the Warren collection reached the American Museum, it was very carefully looked over in a search for remnants of the original tusks, and finally the fragmentary fossil ivory was found, but inasmuch as most of the original records had been lost and no use of these materials had been made by Doctor Warren, it remained to be proved that the fragmentary butts of the tusks really belonged with the skull. The piecing together of these butts required several months of most ingenious and patient work on the part of one of our preparators, Mr. Charles Christman. The ends of each tusk were perfectly preserved, but there was no connection between these tips and the reconstructed butts of either tusk. Fortunately, when the butts of the tusks were sawed off, a single splinter of bone broke off, and finally this splinter was found to fit exactly to a fragment of the butt. There was great rejoicing in the laboratory when the relationship of these two fragments was discovered, because it enabled us to determine positively the length of the tusks as 8 feet, 7 inches.

The rebuilding of the tusks, which required several months of most patient work, had two very important

results: in the first place, it enabled us to place them properly in the sockets of the skull and to prove for the first time the exact relations of the mastodon ivories; secondly, a very painstaking examination of these tusks led to an important and most interesting discovery, namely, that it was possible to determine very closely the age of the Warren Mastodon. The ivory exhibits a series of growth rings which, counted from tip to base, seems to prove that the Warren Mastodon was perhaps thirty years of age at the time it sank into the bed of marl near Newburg. The right tusk included at least twenty-eight of these segments. The growth rings are shortest near the tip of the tusk when the animal is young, and increase in length from the tip toward the middle of the tusk, but not in a regular ratio. These growth rings do not correspond exactly in the opposite tusk, but in both tusks they are longest in the middle region. Nine smaller rings are in the lower part. The writer's theory regarding these growth rings is that during the summer season, when all the conditions of life were favorable, and perhaps during the rutting period, when tusk growth was hastened by internal secretions from the reproductive glands, the growth of ivory was very rapid, the maximum growth in the 17–18 ring being 108 centimeters, of 4¼ inches, perhaps the maximum growth of a favorable season at the most vigorous reproductive period of life. The Warren Mastodon is an adult but not an aged specimen; the skeleton is apparently that of a younger animal than the one represented by the Shawangunk head. Some estimate the maximum age of the American mastodon at between thirty and forty years,—less than half the life span of the elephant, which attains more than one hundred years.



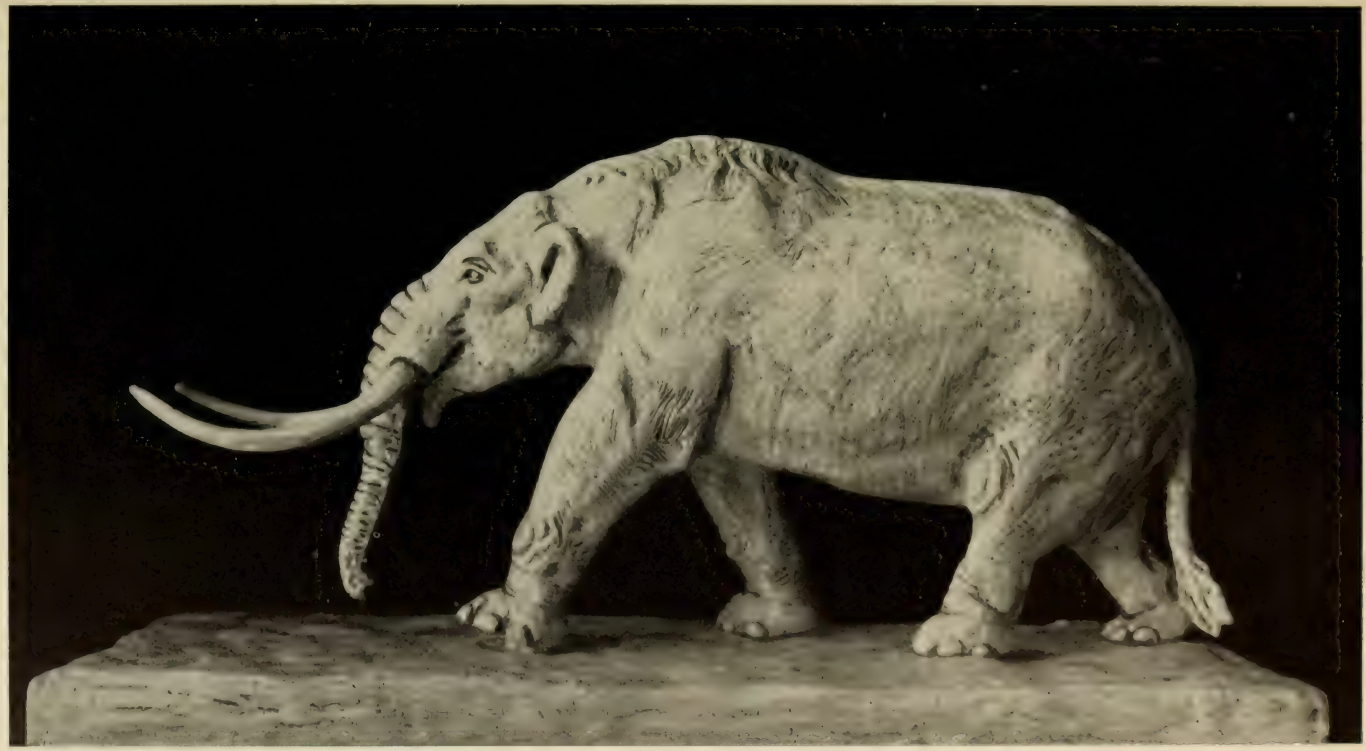
In repairing the tusks of the Warren Mastodon, it was found that the outer sheathing of the ivory (dentine) was in large part absent; the inner sheathing exposed a series of concentric constrictions and expansions which were observed to be approximately symmetrical on the two sides, as indicated by the two series of + signs in the lower figure. In the second place, it was noted that the intervals between these constrictions are broader in the middle stages of the growth of the tusk and narrower in the mature or later stages of its growth. On the hypothesis that these are actual annual increments of growth, the right tusk (A) consisted of about twenty-eight segments, which, allowing for the period of milk teeth and for the part worn off at the tip, would assign to the Warren Mastodon an age of perhaps thirty years

THE WARREN MASTODON AS REMOUNTED IN THE AMERICAN MUSEUM IN 1908

The skeleton is so complete that the only restorations or replacements which have been necessary are the following: caudal vertebræ 1–14, 16–28; all the terminal phalanges of the left forefoot except digit iii; and phalanx 2, digit iv, of the right forefoot. The following bones are introduced from other individuals: two posterior sternal bones, phalanx 2 on digits ii, iii, and v

MEASUREMENTS OF THE WARREN MASTODON

	Feet	Meters
Length, base of tusks to drop of tail	14 ft. 11 in.	4.55
Height to top of spines of back at the shoulders	9 ft. 2 in.	2.80
Tusks: Length of right tusk, on outside curve	8 ft. 6 in.	2.50
Length of tusk exposed	7 ft.	2.14
Thigh bones: Length of right	3 ft. 5 in.	1.05
Length of left	3 ft. 6½ in.	1.08
Pelvis or innominate bones: width	6 ft.	1.83



MODEL OF THE WARREN MASTODON BY CHARLES R. KNIGHT

This reconstruction made by Mr. Knight under the direction of Prof. Henry Fairfield Osborn, 1912–14, is one of a series of models of the extinct and living elephants, and of the mastodons, made to a uniform scale of 1½ inches to the foot, or a $\frac{1}{8}$ scale. The heights of these animals in descending order are as follows:

Imperial mammoth, *Elephas imperator*,	13 feet, 6 inches
African elephant, *Loxodonta africana*,	11 feet, 8½ inches, record of Rowland Ward
Indian elephant, *Elephas indicus*,	10 feet, 6 inches, record of Rowland Ward
Jeffersonian mammoth, *Elephas jeffersonii*,	10 feet, 6 inches, type specimen, American Museum
Woolly mammoth, *Elephas primigenius*,	9 feet, 6 inches, type specimen of western Europe
American mastodon, *Mastodon americanus*,	9 feet, 2 inches, as measured from the Warren Mastodon
Pigmy African elephant, *Loxodonta pumilio*,	6 feet, 2 inches, height of specimen in the New York Zoological Park

GROUP OF AMERICAN MASTODONS ALONG THE MISSOURI RIVER IN KANSAS

This restoration was made by Mr. Charles R. Knight, in 1920, under the direction of Prof. Henry Fairfield Osborn. There are two mastodon bulls, a cow, and a calf in the scene

"THE COHOES MASTODON" AS HE APPEARED IN LIFE

This restoration is based on the most careful study of the muscular anatomy and proportions of the animal as derived from exact measurements of the skeleton, aided by comparison with the external form, skin texture, and other details in living elephants. The American mastodon had a coat of hair which somewhat resembled the hair of present-day elephants, though very much thicker and longer. The animal was thus adapted to the low temperature which prevailed in this region at the breaking-up of the Ice Age. It was a very distinctive member of the New York fauna of a few thousand years ago when mastodons may have roamed the swampy regions in herds comparable in number to those of the buffalo on the western plains fifty years ago. Parts of more than one hundred skeletons have been discovered in this state. This is the only life-size scientific restoration that has been made of the American mastodon.

Executed, under the direction of Dr. John M. Clarke, by Messrs. Noah T. Clarke and Charles P. Heidenrich for the State Museum at Albany in 1921–22

It was very important to make another correction in mounting this animal, namely, to ascertain its exact height at the shoulders. The temptation of preparators has always been to make both mastodons and elephants much larger than they actually were in life by raising the chest portion high above the tips of the shoulder blades. In order to determine this much-mooted question, our preparator at the time, Mr. Adam Hermann, spent a day on the back of Gunda, then the favorite riding elephant of the Zoological Park; placing his two thumbs on the tip of the spine and his two index fingers on the tip of the shoulder blades, he was able to note that the shoulder blades are on practically the same level as the summit of the spine. This observation enabled us to determine positively that the height of the backbone of the Warren Mastodon at the tip of the spine is 9 feet, 2 inches above the ground, whereas the length of the animal from the skull measured at the very base of the tusks to the droop of the tail is 14 feet, 11 inches, practically 15 feet. Thus the length of the animal's body is 6 feet, 9 inches greater than its height at the withers. Its proportions are thus totally different from those of any species of elephant. The long, low body is correspondingly broad, with an immense spread of six feet across the hips of pelvis. It is to emphasize the long, low, and broad proportions of the American mastodon, that the accompanying restorations were made by Charles R. Knight, under the writer's direction.

The reader who is interested to learn more about this subject is referred to works by Warren and others in the Osborn Library of the American Museum of Natural History, and especially to an article by Dr. John M. Clarke entitled "Mastodons of New York. A List of Discoveries of Their Remains, 1705–1902," in the Report of the State Paleontologist, 1902, New York State Museum. Bulletin, 69, p. 921.

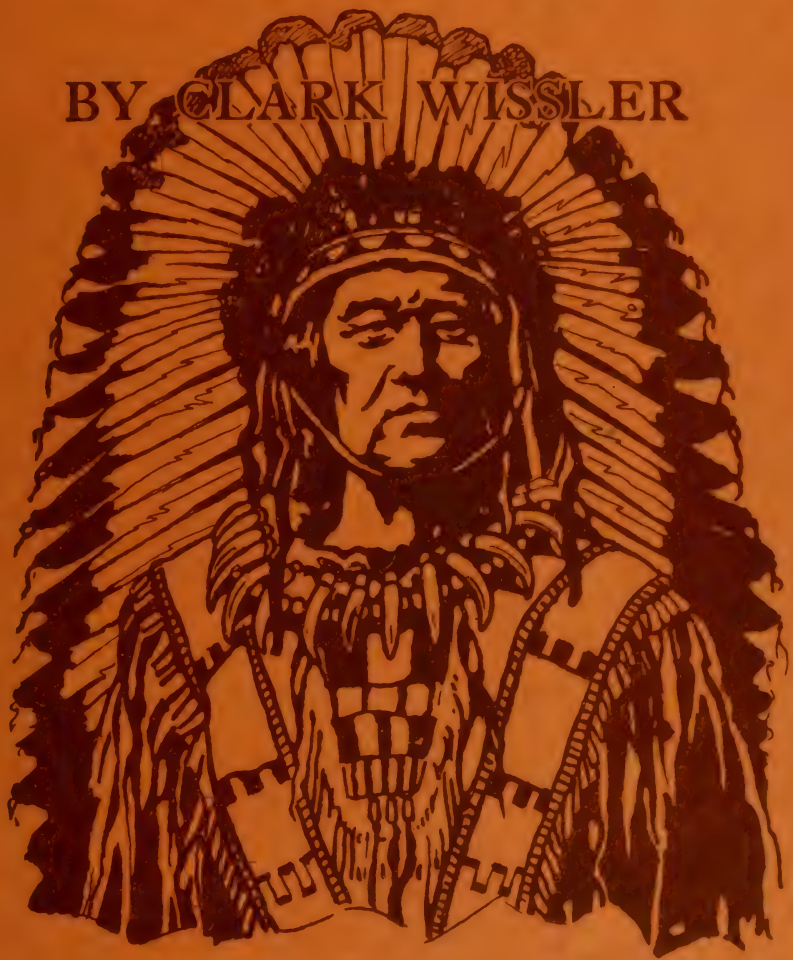
FOR THE PEOPLE

FOR EDUCATION

FOR SCIENCE

INDIAN COSTUMES IN THE UNITED STATES

BY CLARK WISSLER



GUIDE LEAFLET SERIES No. 63

THE AMERICAN MUSEUM OF NATURAL HISTORY

NEW YORK. N. Y.

After Maximilian

Fig. 1. A Mandan Chief.

INDIAN COSTUMES IN THE UNITED STATES

A GUIDE TO THE STUDY OF THE COLLECTIONS IN THE MUSEUM

By CLARK WISSLER

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INTRODUCTION

To get at a true understanding of native Indian costume one must look at the whole of the New World. To us, clothing means textiles, woven stuffs, but such materials were used in pre-Columbian days nowhere outside of the highlands of Mexico and South America, except in what is now New Mexico and Arizona, the area of true cloth.

Yet, there was one peculiarity to clothing made of these prehistoric textiles; the cloth was not cut and sewed by a tailor, but the garment was woven in about the shape in which it was to be worn. Naturally, this reduced all styles to straight lines and right angles. So we can say that all the textile costumes of the aborigines were non-tailored.

In other parts of the Americas the materials were chiefly the skins of animals. However, the users of skins fall into two classes, those who are tailors and those who are not. The Eskimo are true tailors, since skins are cut according to patterns and skilfully fitted to the body, so that in every respect their work compares favorably with that of our own tailors. The Canadian Indians, also, living next to the Eskimo, show almost equal skill, but as we move south through the forests of Canada, we note less and less skill in the tailor's art and in northern United States it vanishes, or becomes excessively crude. No Indian in what is now the United States made a sleeved garment like a coat, except a few of those along the Canadian border. Nor did such a thing as a skin coat appear in all of South America.

The picture we get, then, is that of a central group wearing cloth costumes, surrounded by a naked people who bundled themselves in skins when necessary, while in the extreme north were tribes who knew how to make well fitting coats and trousers of skins. So we see that if we wish to study the original costumes of Indians in the United States, we will, in the main, have to deal with a people who for the most part went naked and protected themselves from the cold by wrapping up in skin robes. "Naked savages," the colonists called them, and with much truth.

Now, while we have defined the basic character of Indian costume, we must prepare ourselves for a variety of styles, even tribal differences. As to what these differences were in prehistoric America cannot be completely stated. To say just what individualities in style prevailed in Manhattan Island, for example, when Hudson arrived here, is next to the impossible, but since, as we have seen, the more basic elements in a style tend to spread over a great stretch of country, we can be confident

that the general plan of costume say, for New York and New England, can be determined from the writings of explorers, supplemented by later studies among the Indians themselves. Yet, we must be continually on our guard, for the white traders sought to introduce their wares from the first and the missionaries set their faces resolutely against the exposure of any part of the body. And the Indian was always keen for a new style. Yet the effort in this brief study will be to state the styles prevailing when the first explorers arrived.

COSTUME MATERIALS

Little in the way of weaving was to be found in the aboriginal United States, except among the Pueblo dwellers of the Southwest, who raised some cotton. Yet, there is reason to believe that some cloth was made in the lands skirting the Gulf of Mexico, but these are the exceptions, skins of deer and other animals serving as the basic materials. All early writers are loud in their praise of the beautiful soft-tanned deerskins prepared by the Indians, a very fine costume material, indeed.

One of the most important aspects of costume is color, and, it is not strange that though skins were used throughout the area under consideration, these were made white, yellow, etc., as desired. In the account of De Soto's expedition, we read:—

> The skins are well dressed—the color being given to them that is wished—and in such perfection that when of vermilion they look like very fine red broadcloth; and when black—the sort in use for shoes—they are of the purest. The same hues are given to blankets [1]

If we add feathers and soft barks of trees and grasses, the list of costume materials will be complete.

THE FORESTS AND THE PLAINS

Since most readers are familiar with the Indians east of the Rocky Mountains, we will give our chief attention to their costumes. This part of the United States presents two rather different environments, the plains and the forests, each of which has influenced dress and ornamentation. Nevertheless, the costume of these two areas is similar when compared with the remaining more specialized regions, as the Southwest, California, and Alaska. Perhaps one should say they are similar because made of skins, for all the Indians of the Plains and Forests were hunters, some exclusively so, and others, though varyingly engaged in agriculture, still chiefly dependent on the chase. Two halls in the Museum house the exhibits for the Indians of our eastern forests and of the western plains. Costumes are shown there, but none of these were made before 1492 and few, if any, more than a hundred years ago. Yet, many of them are prehistoric in style, or show no European influence.

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[1] *Narrative of the Career of Hernando de Soto* (Translated by Buckingham Smith, New York, 1866), 53.

Headgear

One naturally thinks of an Indian as decked with feathers, and this was varyingly true of all tribes east of the Rocky Mountains, though most accentuated in the Plains. Yet nowhere was feather headgear the regular costume, but rather was it worn as regalia or insignia. Both sexes were innocent of hats or caps. It is a little surprising not to find these objects, for nothing seems more necessary to use in winter than a hat or a cap, yet it is not until we reach the Canadian border that such things come to notice. There in Colonial times we find a kind of cap, which the French called a *capote*, but just what form this took in prehistoric times we do not know. So, in the Plains and Woodlands of the United States, the only protection to the head was that afforded by the robe which could be pulled up over the head, if desired.

Fig. 2. Seminole Hair Dress. The sides of the head are cropped close, leaving a ridge of hair on top and a similar border to the face. After Macauley.

Now that heads were bare, we may expect some developments in hair dress and ornaments. The women rarely cut the hair, except in mourning; but we find a widespread tendency among the men to shave, or crop close, the hair from the sides of the head, leaving a ridge or roach in the middle, like a cockscomb. Judging from the earliest accounts such a tonsure prevailed among all tribes between Lake Champlain and Georgia and westward far out into the Plains. No doubt there were varieties in this style, but that surviving among the Seminole to recent times is the same as that in the drawings of John White, 1584.

One item should be noted, however, that the Indians about New York and in New England made an artificial roach of deer hair. Gookin says, "deer shuts made in the fashion of a cock's comb dyed red and crossing their heads like a half moon."[1] (See illustrations.)

Headdresses of this character are still worn in a dance popular among the Plains Indians (see exhibits in Plains Hall). It is reasonable to suppose that originally a roach of natural hair was worn and that from this developed the idea of the artificial roach.

Again in the north the hair was gathered into a knot at the back of the head. In the south, on the other hand, the knot was drawn

[1]Willoughby, C. C. "Dress and Ornaments of the New England Indians" (*American Anthropologist*, N. S., vol. 7, pp. 499–508, 1905), 505.

up on top of the head. In the Upper Mississippi Valley and around the Great Lakes the men wore their hair long and braided.

As we have stated, the women throughout wore the hair long and hanging down or braided. In early times, in the north as well as the

Fig. 3. Fox and Sauk Indians about 1840, with Hair shaved except for a Stubby Roach to which is attached an Artificial Roach of Deer Hair. After Maximilian.

south, the front hair was sometimes cut off like "bangs." Some of the young men of the Upper Missouri practised a form of this in Catlin's time.

Headbands and Feathers. If the reader will consult the successive cases in the Woodland Hall, it will appear that a black headband set with a row of feathers is the rule. Now it so happens that one of the early writers states that many wore such bands of skins dyed black.

Perhaps then what we see in museum collections is merely a change from skin to cloth, adding ornaments of trade beads.

A very curious diadem or band, about four inches broad, and ingeniously wrought or woven, and curiously decorated with stones, beads, wampum, porcupine quills, etc., encircles their temples; the front peak of it being embellished with a high waving plume, of crane or heron feathers.[1]

Fig. 4. A Mohawk Indian showing Hair Dress and Toga-like Garment. Colonial Period. Jeffrey's Collection.

The unusual turban-like cap (modern), still worn by the Seminole, reminds one of Old World styles, from which source it may have been derived.

Feather Hats. During the period 1800–1900 the feather hats of the Siouan tribes and their neighbors have been the most conspicuous. We do not know that they were so large and handsome before 1800, probably they were much smaller then. Anyway, it is certain that the coming of the horse stimulated their elaboration.

---

[1]Bartram, William, *Travels through North and South Carolina, Georgia, East and West Florida, the Cherokee Country, the Extensive Territories of the Muscogulges or Creek Confederacy, and the Country of the Chactaws* (London, 1792), 499–500.

The feather headgear of the Forest Indians was different; it had no tail, but did circle the head. Both eagle and turkey feathers were used. They stood erect, rather than drooping backward as in the Plains.

In the south the hair was more frequently gathered on top of the head in a knot and from the old drawings it seems that a kind of band, or chaplet, was worn, into which feathers were stuck. This is no doubt the original form of the feather hat.

Fig. 5. King Philip. A portrait of the time from which it appears that this famous chief wore a shirt of European style and presumably of cloth. Otherwise, the costume follows aboriginal lines. After Thomas, Elementary History of the United States.

Ornaments. Tying things to the hair was universal, but aside from feathers, individuality prevailed to such an extent that it is well nigh impossible to treat the subject here. Skins of birds, claws of animals, shells, etc., were used according to the taste or superstition of the wearer.

a b

Fig. 6. a, A Mexican Indian wearing a Cape and Skirt of Turkey Feathers. The headdress is probably Spanish in origin, but the feather garments are similar to those of Indians in Eastern United States; b, A Delaware Indian of the Colonial Period wearing Aboriginal Headdress. From old prints, Jeffreys Collection.

Boring the ears seems to have been universal and especially in the south the lobe was greatly distended for the insertion of large disks and ornaments. Speaking of the Southern Indians, Jones states:—

Not only were the ears slit for the reception of inflated bladders, eagles' claws, feathers and various ornamental pendants, but in some instances the nipples and under lips were bored so that canes and other matters for personal adornment might be introduced and worn. The nose was perforated to admit of the suspension of ornaments from the cartilaginous wall which separates the nostrils. It would appear

that lip-stones (called by the Spanish *bezote* and by the Mexicans *teutetl*) were worn at least to a limited extent.[1]

The bladders mentioned are shown in De Bry's plates.

In New England the ears were pierced, but not so distended, the ornaments being smaller, and the same can be said for the tribes westward into the Plains. The nose was rarely pierced, nor is their evidence

Fig. 7. Headdress of Drooping Feathers. A Museum specimen collected from the Sioux Indians in 1838.

for the labret, these being characteristic of the south. Nevertheless, in the extreme western limit of the Plains are the Nez Percé Indians, who did perforate the nose as did some of their neighbors.

Beads were chiefly of shell, pearl, and occasionally of copper. Apparently all such ornaments were rare and costly and so limited to the favored few, but the coming of the trader with new tools, etc., quickly cheapened beads and made them universal. Speaking of wampum

[1]Jones, C. C., *Antiquities of the Southern Indians* (New York, 1873), 88.

Bradford wrote in 1627 that its use was limited to "ye sachems and some spetiall persons that use a little of it for ornament," but a little later it became plentiful and cheap.

The use of face paint was universal, but tattooing seems to have been most intense in the south, as some old sketches show the chiefs tattooed from head to foot like Polynesians. Some of the chiefs in New

Fig. 8. The First Sketch shows the Winter Garment for Southern Indians, merely a Rectangular Robe of Dressed Skin hanging over the Left Shoulder. The Second, the Ceremonial Dress of the Same Region, a Small Apron Before and Behind. John White. 1585.

England were also so adorned and so were they in parts of the Plains. But the elaborate tattooing disappeared quickly with the adoption of Colonial costumes. Even in aboriginal times tattooing seems to have declined as one moved northward, for, where the body was well covered part of the year, tattooing would serve no good purpose. A moderate amount of face tattooing was well nigh universal.

Under Garments

The breechcloth was universal for men, and for the most part, women also. A Dutch writer in 1671 says: "The men wear between the legs a lap of duffels cloth, or leather, half an ell broad and nine quarters long; so that a square piece hangs over the buttocks and in front of

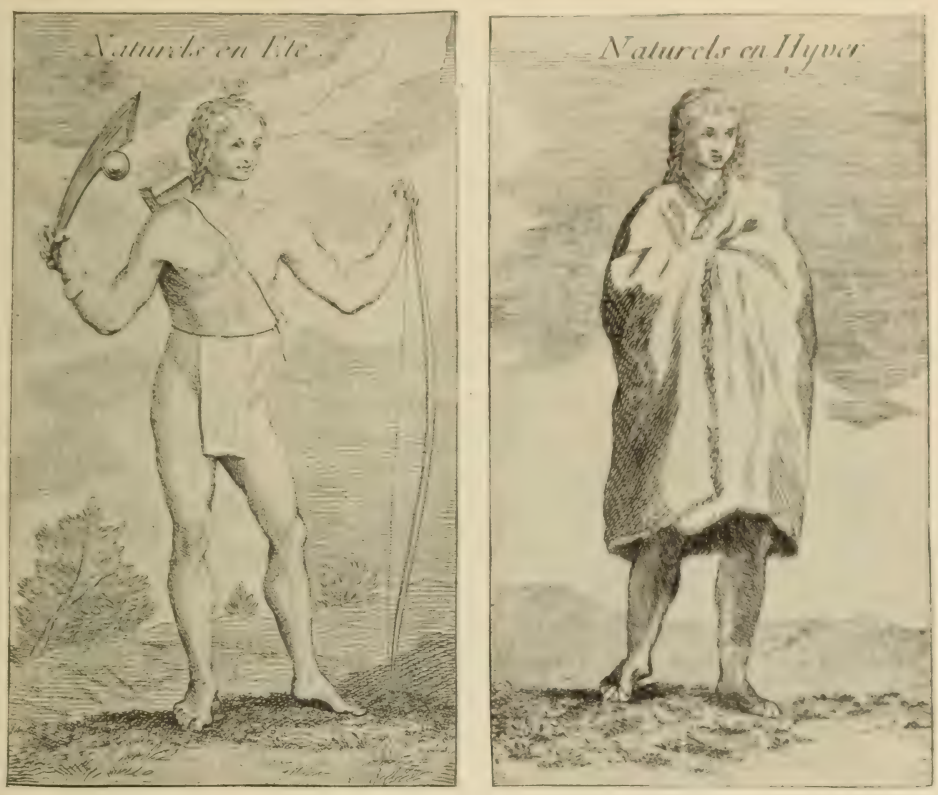

Fig. 9. An Old Print contrasting the Summer and Winter Costumes in Louisiana. After Du Pratz.

the belly." With few exceptions this will hold for all tribes in the United States east of the Rocky Mountains.

According to White's sketches both women and men in Virginia wore a kind of apron before and one behind, but one cannot make out whether these are the ends of the breechcloth, or an additional garment.

Skirts. The women in New England usually appeared in Colonial times with a short skirt formed by wrapping a skin around the waist. This rarely came below the knee. Such seems to have been the original form of the Algonkian, or Eastern, slit skirt, which appears in Colonial times in cloth. (See exhibits.) Such a skirt is merely a rectangular piece brought around the waist, and its use seems to have extended out

Fig. 10. Costumes of Southern Indians from Drawings by John White, 1585.

across the Mississippi and down into the South. Yet along the Gulf some weaving was practised, for we are told that the aprons or skirts were sometimes of native woven stuffs.

Upper Garments

In the house and in mild weather, the Indians wore nothing above the waist line,—men and women the same. As stated before, no good evidence exists that a coat or jacket with sleeves was used below the Canadian border.

In New England and the Central States jackets and shirts appear early in Colonial times, but the styles indicate European origins. It may be, however, that a kind of sleeveless poncho was worn, as reported by Parker.[1] The accounts of the Dutch indicate that originally sleeved garments were unknown.

Fig. 11. Female Costumes in Southern United States. The garment is shown as a rectangular piece of dressed skin. After Du Pratz.

Robes. Instead of jackets, shirts, and coats, both men and women wore, when needed, a robe.

Mantles or robes were made of the skins of the moose, deer, bear, beaver, otter, raccoon, fox, and squirrel, and were worn by both sexes. Beautiful cloaks were manufactured of the iridescent feathers of the wild turkey, 'woven with twine of their own

[1]Anthropological Papers, American Museum of Natural History, vol. 17, part 2, 80.

making,' so that nothing could be seen but feathers. These cloaks were usually the work of the old men, but sometimes were made by the women for their children.

When in the vicinity of Wellsfleet harbor, Massachusetts, Champlain saw robes woven of 'grass and hemp scarcely covering the body and coming down only to the

Fig. 12. Woman and Girl of the Plains. The woman is muffled in a painted robe of buffalo skin. The girl's dress is a replica of the prevailing style for women in 1840. After Maximilian.

thighs.' These were probably identical with the silkgrass mantles of the southern Algonquians illustrated by John White in 1585.

A single skin of the moose, deer, or bear served for a man's robe. Moose skins were commonly dressed without the hair and were made 'wondrous white,' . .

[1]Willoughby, *ibid.*, 502–503.

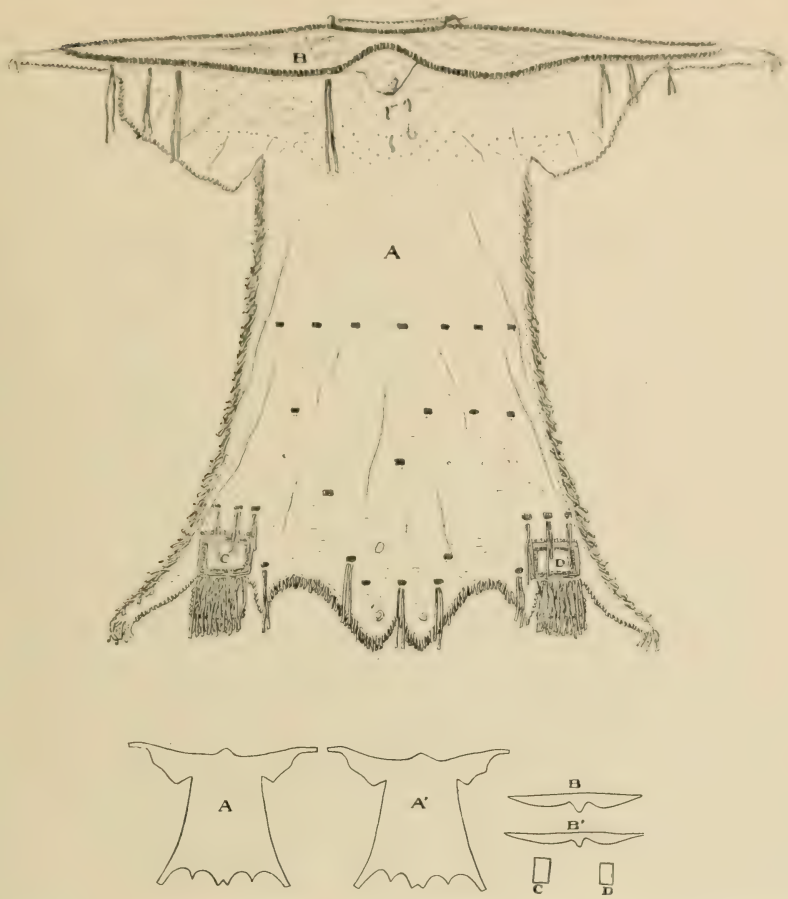

Fig. 13. A Woman's Dress, Crow. An entire elkskin is taken for each side. A cape-like yoke is formed of two pieces as above, and sewed in place. It is interesting to note that the form of dress follows the natural contours of the skin.

Deer-skin mantles were dressed with or without the hair, and a perfect tail greatly enhanced their value. In winter the hair was worn innermost. Those especially prepared for summer wear were dressed usually without the hair. These garments were fastened at the shoulders with leather. They were thrown over one or both shoulders and brought usually under one arm. When traveling they were also secured at the waist with a belt.[1]

[1]Willoughby, *ibid.*, 504.

A long robe fastened at the right shoulder by a knot, at the waist by a girdle, served the men and women for an upper ornament, (sic) and by night for a bed cover. Both go, for the most part, bare headed.[1]

These descriptions agree with the sketches of White and other early artists, and as we go westward the buffalo robe appears. Thus the robe is about as universal as the breechcloth; together, these comprise the fundamentals in aboriginal dress.

The New England and Virginia way of wearing the robe left one arm exposed, over which was worn a sleeve of fur, or a kind of muff. This was held to the robe or neck by a cord, probably a northern idea, as we shall see.

Mantles of Turkey Feathers. One of the most striking garments of the Atlantic Coast was a cape, or mantle, of turkey feathers. Such were worn from the New England southwestward to California. Not a single specimen has been preserved and they seem to have disappeared quickly upon the coming of the whites. Yet we hear that a net was "woven with twine of their own making" and the feathers fitted to this so that they hung down naturally. Such garments seem to have been common in Mexico and we are able to reproduce an old drawing here.

Shirts. A type of woman's costume, best observed in the Plains is like a poncho, or shirt, a one piece garment reaching from shoulder to below the knee. There are, however, two rather distinct forms: *a*, the Plains; *b*, the Cree-Ojibway type.

The Plains type is without true sleeves. Taking a Crow specimen as the type (Fig. 13) we see that three pieces of skin are used: an inserted yoke and two large pieces for the skirt. The sides are sewed up from the bottom of the skirt almost to the cape-like extension at the shoulders. There are no sleeves, but the cape-like shoulder piece falls down loosely over the arms. The side seams and the bottom and all outer edges are fringed. The garment has neither front nor back, both sides being the same.

The technical concept is a garment made from two whole skins, in this case, elkskins. A dress is formed by placing two whole skins face to face, the tail ends at the top, the head at the bottom. The neck is fitted and the yoke formed by the insertion of a transverse piece of skin. Very little trimming is needed to shape the sides of the skirt.

The distribution of this pattern concept so far as we were able to determine by the study of specimens is: Apache, Arapaho, Assiniboin,

[1]Skinner, Alanson, *The Indians of Greater New York* (Cedar Rapids, Iowa, 1915), 22, quoted from O'Callaghan, *Documentary History of New York.*

Blackfoot, Cheyenne, Comanche, Crow, Dakota, Gros Ventre, Hidatsa, Kiowa, Nez Percé, Northern Shoshoni, Plains-Cree, Sarsi, Ute, Yakima.

In the Cree-Ojibway type the shoulder cape is missing, thus leaving a skirt, supported over the shoulders by straps, or the edges of the skin tied together.

Fig. 14. Sketch of an Ojibway Girl of about 1850. The style of dress intended to be portrayed is a simple sleeveless garment supported by straps over the shoulders. The separate cape-like sleeves are also shown. After Schoolcraft.

The coat, or body covering, falls down to the middle of the leg, and is fastened over the shoulders with cords, a flap or cape turning down about eight inches, both before and behind, and agreeably ornamented with quill-work and fringe; the bottom is also fringed, and fancifully painted as high as the knee. As it is very loose it is enclosed round the waist with a stiff belt, decorated with tassels, and fastened behind. The arms are covered to the wrist, with detached sleeves, which are sewed as far as the bend of the arm; from thence they are drawn up to the neck, and the corners of them fall down behind, as low as the waist.[1]

[1]Mackenzie, Alexander, *Voyages from Montreal, on the River St. Lawrence, through the Continent of North America, to the Frozen and Pacific Oceans, in the years 1789 and 1793, etc.* (London, 1801), XCIV.

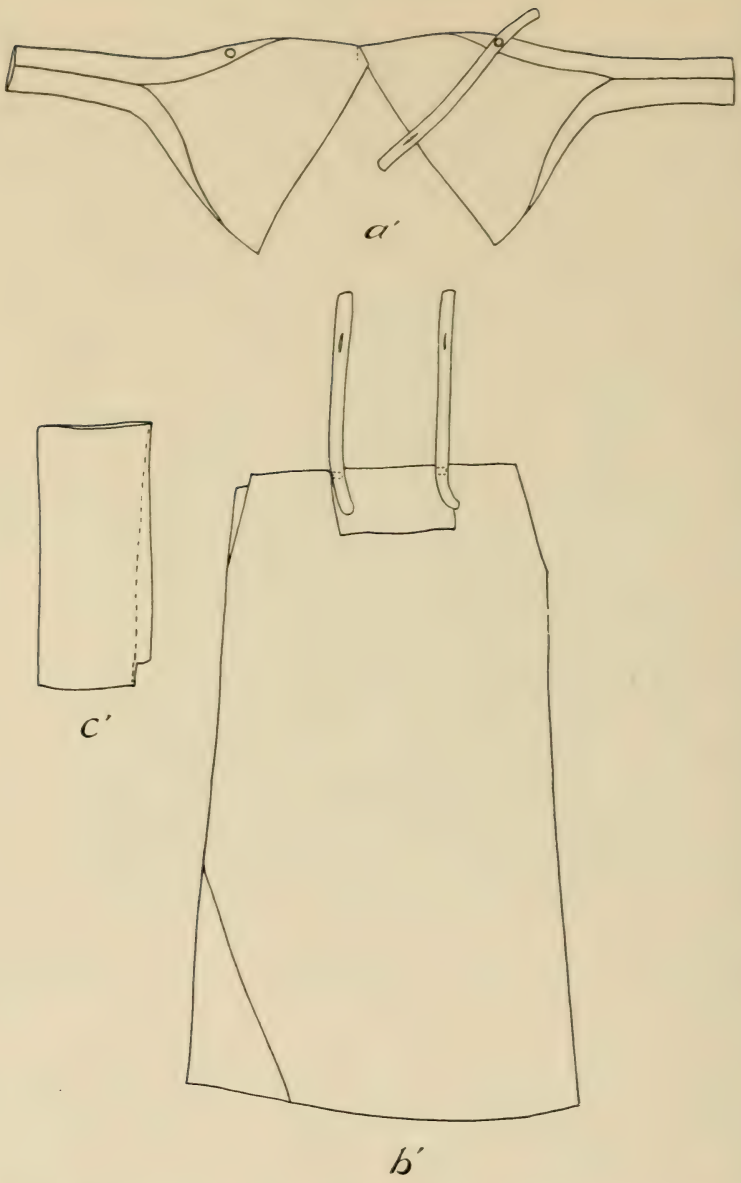

Fig. 15. Pattern of a Deerskin Dress from the Saulteaux Indians, similar to the one shown in the Sketch of an Ojibway Girl.

These sleeves held by a cord remind one of the men's sleeve in the east, to which they certainly have some relation

On dress occasions the distinguished men of the Plains wore shirts, also made of deerskins (Fig. 16). In this case, however, the forequarters of the skin are cut off and sewed to the sides forming an open sleeve as

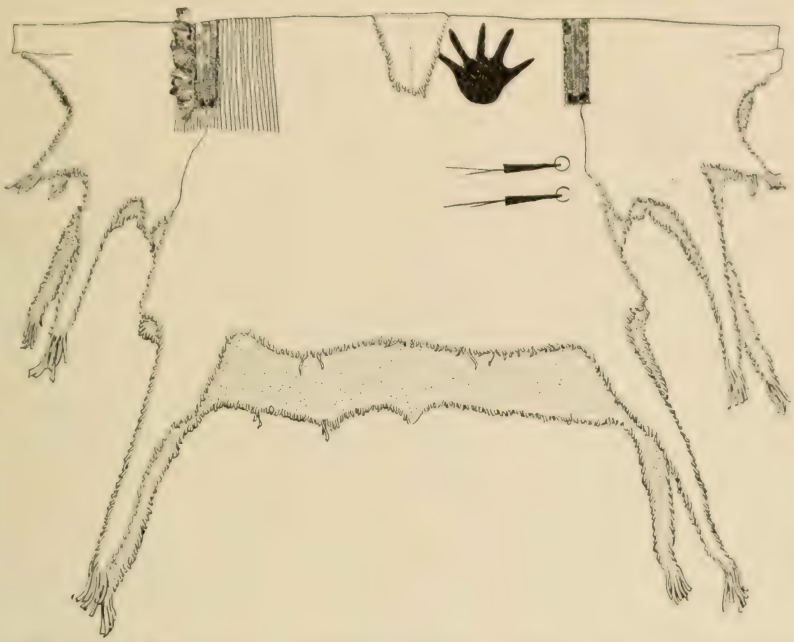

Fig. 16. A Man's Shirt of the Poncho Type. This specimen is made of two deerskins. There are bands of quillwork over each shoulder, fringed on one side with crow feathers. On the opposite side of the fold is a transverse band of quillwork. See Bulletin of this Museum, vol. 18, fig. 95. The tail tuft is discernible on the lower edge and the dewclaws are still attached to the leg projections. Collected in 1838.

for women. More modern specimens have the lower part of the sleeve closed. All the Plains tribes used this shirt, as well as the Apache and Taos on the south and the Ojibway on the northeast. They vary somewhat in decoration as may be seen in the exhibits.

We repeat that these shirts were only worn on special occasions and by a few men; otherwise, except in the northeastern Plains, no upper garments were worn.

Wallets

In addition to the belt for holding the breechcloth, a girdle was often used to hold the robe. To this were attached useful objects, but special mention should be made of pouches.

The men wore at the girdle a pouch of dressed skin containing fire-making implements. A pipe and tobacco were also carried in the pouch, which was sometimes suspended from the neck.[1]

Fig. 17. A British Footguard, 1745. A comparison of the bandolier on this figure with those in the Indian collections is suggested. Sketch from Grant's "British Battles."

The pouch offered a field for decoration and among the Plains Indians became a very important feature of formal dress.

Among the collections from the Forest tribes one may note large showy pockets with shoulder bands, sometimes called "bandoliers." These are assumed to be of European origin, but still appear very early in Colonial days. The form of this pocket closely parallels that used by soldiers of the period (Fig. 17) as seen in the illustration. These very decorative articles must then be regarded as innovations in Indian costume and not mere adaptations.

Footgear

The footgear of the Indian is far better known than other parts of his costume. A moccasin was worn throughout the forests and the plains; but along the Pacific Coast, from Alaska to Mexico, the people went barefoot most of the time. In the desert lands of the Southwest and in Mexico sandals were worn. Our present concern then is with the moccasin. The earliest pictures of Indians from Virginia to the south show everybody barefoot, but we are told that moccasins were often worn. On the other hand, from Virginia northward moccasins were the rule.

Leggings were used by both sexes, especially in the north, but for a true boot one must go to the Eskimo. In New England and apparently in all the upper Mississippi region, the men wore a long legging reaching far up on the thigh and held by a string to the belt, supporting the breechcloth.

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[1]Willoughby, *ibid.*, 505.

In addition to the breech-clout it was customary for the men, and sometimes for the boys, to wear close-fitting leggings of tanned deer skin. These were worn for warmth in cold weather, on dress occasions, and by hunters as a protection from brush and briers. Their lower ends were fastened within the moccasins and their upper extremities were secured by straps to the girdle, which was sometimes ornamented with pendants or 'set with forms of birds or beasts.' The leggings were ornamented with designs in yellow, blue, and red. The women also sometimes wore leggings.[1]

This description, culled from old writers, is repeated by the Dutch observers and if one views the collections in the Museum it will be seen to hold for all tribes east of the Rockies. The leggings for women rarely come above the knee and were held up by a string garter.

Moccasins. The local types of moccasins have been carefully studied by Mason and Hatt.[2] In the main the moccasins of the forest had a soft sole, like a stocking; while those of the plains had a stiff sole like a slipper. The body of the former was made of a single piece of skin with the folds and seams on top of the foot and what varieties are found are produced by change in the flap and seams. So, in the main, the form shown in the figure (5) will serve for all the tribes east of the Mississippi. The flaps can be worn down or up.

The moccasin was also subjected to decoration and as such is one of the most conspicuous parts of an Indian's costume. The design usually follows the seams, covers the tongue insert, and the flaps. Seldom are the other surfaces of the moccasin ornamented.[3]

Turning now to the Plains we meet with a soled moccasin, in reality a shoe, but with no heel. The patterns for this type resemble those for shoes and need not be explained. In decoration there are some differences, for now there is a sole line at the side of the foot. This is often ornamented. Yet, in the main, the styles of moccasin designs found in collections from the Plains, are similar to those from the forests; hence, we infer that the Plains type is the more recent.

On the other hand, the practice of beading or quilling the entire surface of the moccasin is peculiar to the Plains, and is also recent.

In both the forests and the plains, there is little distinction in pattern between the moccasins of women and men.

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[1]Willoughby, *ibid.*, 502.

[2]Mason, O. T., "Primitive Travel and Transportation" (*Report, United States National Museum for 1894*, Washington, 1896); Hatt, Gudmund, "Moccasins and their Relation to Arctic Footwear" (*Memoirs, American Anthropological Association*, vol. 3, no, 3, 1916).

[3]Wissler, Clark, "Structural Basis to the Decoration of Costumes among the Plains Indians" *Anthropological Papers, American Museum of Natural History*, vol. 17, part 3, 1916).

Early Accounts

A fair idea of Virginia costume is given by John Smith, as follows:—

For their apparell they are sometimes covered with the skinnes of wilde beasts which in Winter are dressed with the hayre, but in Summer without. The better sort vse large mantels of Deare skins, not much differing in fashion from the Irish mantels. Some imbroidered with white beads, some with Copper, other painted after their manner. But the common sort haue scarce to cover their nakednesse but with grasse, the leaues of trees or such like. We haue seene some vse mantels made of Turky feathers, so prettily wrought and woven with threads that nothing could be discerned but the feathers. That was exceeding warme and very handsome. But the women are always covered about their middles with a skin, and very shamefast to be seene bare. They adorne themselues most with copper beads and paintings. Their women, some haue their legs, hands, breasts and face cunningly imbrodered with divers workes as beasts, serpents, artificially wrought into their flesh with blacke spots. In each eare commonly they haue 3 great holes, whereat they hang chaines, bracelets, or copper. Some of their men weare in those holes a small greene and yellow coloured snake, neare halfe a yard in length, which, crawling and lapping her selfe about his necke, oftentimes familiarly would kisse his lips. Others weare a dead Rat tyed by the taile. Some on their heads weare the wing of a bird or some large feather with a Rattell. Those Rattels are somewhat like the chape of a Rapier, but lesse, which they take from the taile of a snake. Many haue the whole skinne of a Hawke or some strange foule, stuffed with the wings abroad. Others a broad peece of Copper, and some the hand of their enemy dryed. Their heads and shoulders are painted red with the roote *Pocone* brayed to powder, mixed with oyle, this they hold in sommer to preserue them from the heate, and in winter from the cold. Many other formes of paintings they vse, but he is the most gallant that is the most monstrous to behold.[1]

Speaking of the moccasins of the Southern Indians, Jones states:—

The shoes of the men and women were fashioned after the same pattern, and were seldom worn except upon a journey. They were made of deer-skin, the sole and upper leather being of the same piece, and sewed together on the upper part of the foot. The moccasin was cut about three inches longer than the foot, and folded over the toes. The quarters were about nine inches high, and fastened round the leg like a buskin.[2]

Of the women's costume of the Indians living in the vicinity of New York, O'Callaghan in his *Documentary History of New York* writes:—

The women ornament themselves more than the men. And although the winters are very severe, they go naked until their thirteenth year; the lower parts of the girls' bodies only are covered. All wear around the waist a girdle made of a fin of a whale or of seawant (wampum). . . . The women wear a petticoat midway down the leg, very richly ornamented with seawant. . . . They also wrap the naked body in a deer skin, the tips of which swing with points. . . . The women bind their hair in a plait, over which they draw a square cap, thickly interwoven with seawant.[3]

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[1]Quoted in Jones, *ibid.*, 76–77.
[2]Jones, *ibid.*, 79.
[3]Quoted by Skinner, Alanson, *The Indians of Greater New York* (1915), 22.

CALIFORNIA

The standard clothing of California, irrespective of cultural provinces, was a short skirt or petticoat for women, and either nothing at all for men or a skin folded about the hips. The breechclout is frequently mentioned, but does not seem to have been aboriginal. Sense of modesty among men was slightly developed. In many parts all men went wholly naked except when the weather enforced protection, and among all groups old men appear to have gone bare of clothing without feeling of impropriety. The women's skirt was everywhere in two pieces. A rather narrow apron was worn in front. A larger back piece extended around at least to the hips and frequently reached to meet the front apron. Its variable materials were of two kinds: buckskin and plant fibers. Local supply was the chief factor in determining choice. If the garment was of skin, its lower half was slit into fringes. This allowed much greater freedom of movement, but the decorative effect was also felt and used. Of vegetable fibers the most frequently used was the inner bark of trees shredded and gathered on a cord. Grass, tule, ordinary cordage, and wrapped thongs are also reported.

As protection against rain and wind, both sexes donned a skin blanket. This was either thrown over the shoulders like a cape, or wrapped around the body, or passed over one arm and under the other and tied or secured in front. Sea otter furs made the most prized cloak of this type where they could be obtained. Land otter, wild cat, deer, and almost every other kind of fur was not disdained. The woven blanket of strips of rabbit fur or bird skin sometimes rendered service in this connection, although also an article of bedding.[1]

Moccasins "were not worn about the village or on ordinary excursions." Yet they were made and of the general forest type. In Southern California, however, sandals were used.

The typical California moccasin, which prevailed over central and northwestern California, was an unsoled, single-piece, soft shoe, with one seam up the front and another up the heel. . . . The front seam is puckered, but sometimes with neat effect. The heel seam is sometimes made by a thong drawn through. . . . Separate soles of rawhide are sometimes added, but old specimens are usually without, and the idea does not seem to be native. The moccasin comes rather higher than that of the Plains tribes, and appears not to have been worn with its ankle portion turned down. Journeys, war, wood gathering are the occasions mentioned for the donning of moccasins; as well as cold weather, when they were sometimes lined with grass. They were not worn about the village or on ordinary excursions. . . .

The skin legging is rarer than the moccasin. It was made for special use, such as travel through the snow.[2]

Two somewhat unique features are a netted cap for men and basket caps for women. The latter occurs in northern California extending upward to Washington; the former is found chiefly where the basket cap is wanting.

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[1]Kroeber, A. L., "Elements of Culture in Native California" (*University of California Publications n American Archæology and Ethnology*, vol. 13, no. 8, 1922), 260–261.

[2]Kroeber, A. L., "Handbook of the Indians of California" (*Bulletin 78, Bureau of American Ethnology*, Washington, 1925), 805, 807.

With respect to the tribes in the valley of the Columbia River, near the coast, it is stated:—

The clothing used by the natives of this area was relatively simple. The men either wore nothing at all or merely a robe or blanket thrown over the back and fastened across the chest with a string. The women wore a sort of petticoat made of twisted strings of cedar-bark or grass, occasionally of wool, fastened to a cord or band around the waist and falling to the knees. In addition to this they usually wore a robe, smaller than that worn by the men, over the back. Among the Yakonan a similar fringed garment was worn around the shoulders. A hat, usually woven of cedar-bark and grass, was frequently worn, especially in wet weather, when it was also customary to throw a mat over the shoulders for further protection.

The hats of the Chinook and neighboring tribes . . . were closely woven of cedar-bark and grass with some fine cedar-root, so as to be water-tight, and were of a conical shape, surmounted by a pointed knob some two to four inches in diameter. They were ornamented with interwoven designs representing whaling scenes, animals such as dogs and deer, or purely geometrical designs. . . .

The robes and blankets used in this area were usually made of the skins of various animals, or woven (twined) from the wool of the mountain goat. While these were more common northward, woolen robes were also made on the Columbia. . . .

Tattooing occurs to but a slight extent among these tribes, and is usually limited to a few lines or dots on the arms or legs, apparently according to individual fancy. It is more prevalent among the women than the men. The face is rarely, if ever, marked.

Ornaments were commonly worn by both sexes, but especially by the women. Nose and ear ornaments, necklaces, etc., were worn, though it is doubtful if nose ornaments were used by the tribes of Puget sound. Most of these were made of shells, dentalia being the most valued. These form, in fact, one of their most valued possessions, and also serve as a circulating medium.[1]

Usually all these Indians were barefoot.

In the interior, among such tribes as the Yakima, Nez Percé, etc., we find the above type of costume fading out into that of the Plains. Further, since the boundary between the United States and Canada is an arbitrary line, we need not be surprised to find that both the coast and interior types extend into British territory. The Indians of Alaska have a variant of the coast type (see exhibits in the Museum).

[1]Lewis, Albert Buell, "Tribes of the Columbia Valley and the Coast of Washington and Oregon" *Memoirs, American Anthropological Association*, vol. 1, part 2, 1906, 165, 166, 168.

The California type of costume, or want of costume, spreads into Arizona and the Plains type crowds in from the west, as among the Apache; but the Pueblos stand out as rather distinct. This is chiefly due to the presence of woven materials, but when they do resort to skins they tend toward Plains types, except that their moccasins are more like

Fig. 18. Girls from Sia Pueblo in New Mexico. After Mrs. Stevenson.

boots. The women in many villages wear a boot with a top wrapped around the leg to the knee. Sandals were, however, the usual footgear.

The older woman's costume seems to have been without sleeves, but fastened over the right shoulder, leaving the left free. A sash was used instead of a belt. A rectangular robe might be thrown over the shoulders. No hats were used.

The fabrics were woven of cotton and later of wool. Yet, in aboriginal days, robes were sometimes woven of strips of rabbitskin and also the turkey feather mantles used in southern and eastern United States were common.

The men usually cut their hair (bobbed) and wore a band around the head. It is not clear as to the existence of a poncho, or shirt, that seemingly came in with the Spaniards; the essential costume was a short kilt and a mantle or a skin robe.

Quoting from the earliest Spanish accounts, we read:—

Cibola is seven villages. The largest is called Macaque. The houses are ordinarily three or four stories high, but in Macaque there are houses with four and seven stories. These people are very intelligent. They cover their privy parts and all the immodest parts with cloths made like a sort of table napkin, with fringed edges and a tassel at each corner, which they tie over the hips. They wear long robes of feathers and of the skins of hares, and cotton blankets. The women wear blankets, which they tie or knot over the left shoulder, leaving the right arm out. These serve to cover the body. They wear a neat well-shaped outer garment of skin. They gather their hair over the two ears, making a frame which looks like an old-fashioned head-dress.[1]

In their houses they keep some hairy animals, like the large Spanish hounds, which they shear, and they make long colored wigs from the hair, like this one which I send to Your Lordship, which they wear, and they also put this same stuff in the cloth which they make. The men are of small stature; the women are light colored and of good appearance, and they wear shirts or chemises which reach down to their feet. They wear their hair on each side done up in a sort of twist, which leaves the ears outside, in which they hang many turquoises, as well as on their necks and on the wrists of their arms. The clothing of the men is a cloak, and over this the skin of a cow, like the one which Cabeza de Vaca and Dorantes brought, which Your Lordship saw; they wear caps [probably headbands] on their heads; in summer they wear shoes made of painted or colored skin, and high buskins in winter.[2]

Some of these people wear cloaks of cotton and of the maguey (or Mexican aloe) and of tanned deer skins, and they wear shoes made of these skins, reaching up to the knees. They also make cloaks of the skins of hares and rabbits, with which they cover themselves. The women wear cloaks of the maguey, reaching down to the feet, with girdles; they wear their hair gathered about the ears like little wheels.[3]

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[1]Winship, George Parker. "The Coronado Expedition, 1540-1542" (*Fourteenth Annual Report part 1, Bureau of American Ethnology*, Washington, 1896), from *Translation of the Narrative of Castañeda*, 517.

[2]Winship, *ibid.*, from *Translation of the letter from Mendoza to the King*, April 17, 1540, 549.

[3]Winship, *ibid.*, from the *Relatión Postrera de Sivola*, 569.

THE USE OF CLOTH

As stated elsewhere, among the first articles to be offered the Indians, were cloth, shoes, boots, etc. At first, the tendency was to cut the cloth to the patterns for the old skin garments, as a study of the collections will make clear; but eventually the coats, skirts, etc., of the whites introduced new styles. Very early, indeed, the Iroquois took to cotton shirts and coats of buckskin, with brass buttons. The women were a little more conservative, but quickly adopted the waist with sleeves.

Fig. 19. Winnebago Indians. These costumes contain both native materials and trade cloth; in pattern they are hybrids.

In the Ojibway collection are to be found cloth dresses without sleeves, made after the pattern of Fig. 15. The Iroquois and other eastern women wore a shirt formed by wrapping a rectangular piece of cloth around the body, examples of which are on view. Even in the Plains, cloth dresses are to be found.

SOURCES OF INFORMATION

The ideal procedure in the study of costume is to examine the collection in a well stocked museum, but even then it will be necessary to take the literature into account. Thus, if one wishes to know the dress of a given tribe, say the Seminole, he should turn to that title in the *Handbook of American Indians*,[1] where he will find titles of the most important publications. Then, if the dress of a known historical period is desired, that can also be determined. Finally, if the notes thus secured are taken as the basis for a study of museum collections, one will have exhausted all the available sources.

Among general works, the following will be found useful:—

Bry, Theodoro de. Brevis narratio eorum qvæ in Florida Americæ Provicia Gallis acciderunt, secunda in illam nauigatione du ce Renato de Laudoniere classis Praefecto anno M. D. LXIII, qvæ est secvnda pars Americæ. Franceforti ad Mœnvm, 1591.

Catlin, George. Illustrations of the Manners, Customs and Condition of the North American Indians. 2 vols. New York and London, 1848.

Champlain, Samuel de. Voyages ou Journals es decouvertes de la Nouvelle France. Tomes I–II. Paris, 1830.

Hariot, Thomas. A Briefe and True Report of the New Found Land of Virginia of the Commodities and of the Nature and Manners of the Natural Inhabitants. Folis Frankoforti ad Mœnum, 1590.

Jeffreys, T. Collection of the Dresses of the Different Nations (etc.), the complete American Indian portion, being plates 121 to 240. London, 1757–72.

Lafitau, F. J. Mœurs des Sauvages Americains, compares aux Mœurs des Premiers Temps. Tomes I–II. Paris, 1724.

Maximilian, Prince of Wied. Travels in the Interior of North America. Translated from the German by H. Evans Lloyd. London, 1843.

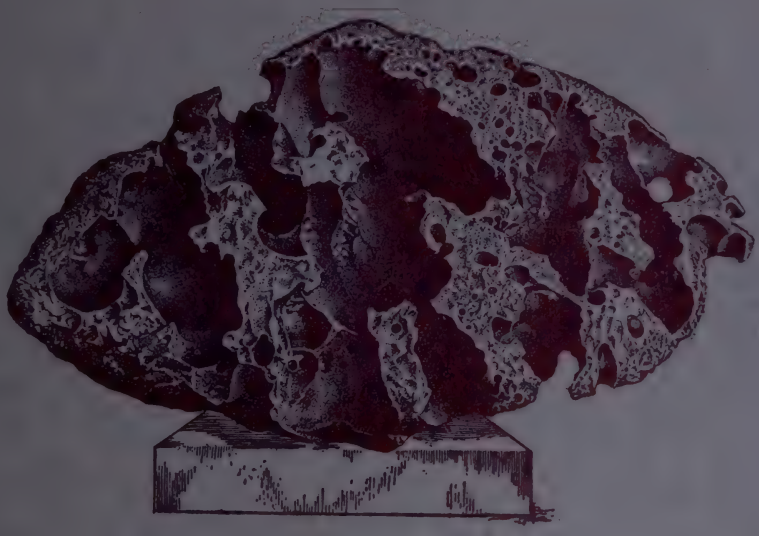
McKenney, Thomas L. and Hall, James. History of the Indian Tribes of North America, with biographical Sketches and Anecdotes of the Principal Chiefs. Embellished with One Hundred and Twenty Portraits from the Indian Gallery in the Department of War at Washington. Philadelphia, 1837–44.

Schoolcraft, Henry R. Historical and Statistical Information respecting the History, Condition, and Prospects of the Indian Tribes of the United States: Collected and Prepared under the direction of the Bureau of Indian Affairs. Vols. 1–6. Philadelphia. 1851–1857.

[1]Bulletin 30, Bureau of American Ethnology.

METEORITES, METEORS AND SHOOTING STARS

By FREDERIC A. LUCAS
Revised by CHESTER A. REEDS



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NEW YORK, N. Y.
1931

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THE WILLAMETTE METEORITE.

The largest meteorite so far found in the United States and the most interesting yet discovered.
Gift of Mrs. William E. Dodge, 1906.

METEORITES, METEORS AND SHOOTING STARS

BY FREDERIC A. LUCAS

When the Willamette Meteorite was brought to the Museum, the attendant in the hall where it was placed was the recipient of many inquiries from interested visitors who wished to know what the (then) unfamiliar object was. Finally, in self defense he placed on it a card: "This is a piece of a star," a statement which if not strictly accurate was one that embodied the most information in the fewest possible words. And if sticklers for accuracy complain that this is a very incorrect definition they may be reminded that it is not nearly so misleading as that of the chemist Lavoisier who, so late as 1772, reported on a specimen submitted to a committee of the French Academy, that it was only a common stone that had been struck by lightning. For those who wish a brief and authoritative statement as to what meteorites are, one cannot do better than quote from the general label on the meteorites, a label read daily by scores of visitors and an admirable refutation of the mis-statement that visitors won't read long labels—they will, provided the subject is of interest and the label well-written.

To borrow from Dr. E. O. Hovey, meteorites, as we know them, are bodies of iron or stone, ranging in size from particles of dust up to masses of 30 tons weight, that circle through space like little planets. Ordinarily they are too small to be seen, but when they enter the earth's atmosphere, as thousands of them do daily, become visible through being made hot from the friction of the air. The small meteorites burn up when far above the earth and are the familiar "shooting" stars; the larger masses, known as meteors during their glowing passage through the air, often reach the earth as meteorites. These falls are accompanied by dazzling light and usually, or often, by violent explosions, due to the breaking up of the mass, and so loud that they have been heard at a distance of sixty to one hundred miles.

The molten particles given off by meteors as they hurtle blazing through the air fall like rain in the form of minute drops, and when this occurs over the ocean these particles sink to the bottom, and at great depths, where, not disturbed by currents, this cosmic dust, as it was termed by Sir John Murray, has in time accumulated in places to form a perceptible, if small, portion of the ocean floor.

Where do meteorites come from? What is their origin? This is something of which we are quite ignorant, though there are some plausible theories concerning them and others not so plausible. Perhaps the most favored explanation was that meteorites were ejected by volcanoes

variously located according to the imagination of the theorist, on the earth, the moon or the sun.

As for their earthly origin it was shown that to get them outside the attraction of the earth they must be cast forth with a speed of five miles a second, a much greater explosive force than shown by any volcano, even Krakatoa. The lunar volcanoes have long been extinct and if they were the source of meteorites these must have been ejected ages ago.

In direct opposition to the theory that meteorites *came* from the moon, Mr. Grove K. Gilbert advanced the hypothesis that the vast, circular, low-walled craters with which the moon's face abounds might have been caused by the impact of huge meteorites falling on the luminary.

The view, then beginning to be seriously considered, that the Coon Butte Crater (Arizona) was created by a giant meteor may have led Gilbert to consider this theory, but while he showed that there were good arguments in its favor he abandoned it in favor of the theory that the lunar craters were formed by the fall of "moonlets" that had circled about the moon as satellites. Coon Butte "crater" just referred to is supposed to have been formed by the main mass of the Canyon Diablo fall which has already yielded about 16 tons of fragments ranging from the size of a marble up to a little more than a thousand pounds and scattered over an area of several square miles.

Another view, and the one now accepted, is that the crater was not formed by one immense meteor, but by a mass of small meteorites, and just as a charge of small shot, at short range, will smash through a board, so these little projectiles together drove into the earth and formed the crater—this theory accounts for the failure to find a vast iron meteorite and explains the thousands of fragments of various sizes—but mostly small—scattered over a wide area. The steam produced by the intense heat of this mass of meteorites entering the ground also aided in the formation of the crater by blowing out the disrupted rocks.

For many years past, work has been carried on at Coon Butte, or Meteor Crater, with the hope of discovering and mining the meteor or meteors, and much capital was literally sunk in borings for this purpose. Mr. D. M. Barringer has been in charge of the work of exploration, and his report, made in January, 1926, announced, "Eventually this hole (the last boring sunk through the south rim, it having been determined that the mass approached from the north at an angle of approximately 45°) encountered what is beyond doubt the upper part of the buried cluster of iron meteorites, finding it exactly in the predicted position.

"The work . . . was (thus) successful in locating the hidden meteor and in pointing the way for future exploration."

Mr. Barringer also explains another point: "it has been generally supposed that the search for this meteorite was for the purpose of obtaining a quarry of pure iron," but we are told that "It must not be thought there is expectation of mining solid iron . . . the iron, as iron, would be of little value. It contains, however, enough nickel to render it a valuable ore—from 5 to 6 per cent.—and a small, but valuable, amount of some of the platinoid metals."

Still, what are meteorites? According to some they are fragments of a lost world, shattered by collision with another that had somehow got out of place. But it must have been a world of strange composition, for while analyses of meteorites have yielded no new *elements* yet they have been shown to contain some minerals which are combinations of elements not found upon earth. These are Maskelynite, Schreibersite, Moissanite, Troilite, Daubreelite, Oldhamite.

Yet another idea advanced by men of science was that meteorites were "condensed" out of clouds of dust, particularly from dust ejected by a volcano. This theory was applied to a fall that occurred in Siena in 1794 during an eruption of Vesuvius, but was badly weakened later by the fall of blazing meteors, accompanied by loud explosions, from a cloudless sky.

There is an evident connection between meteorites and comets, especially in regard to their orbits, or the track they pursue through space, but that there is any physical connection between them is doubtful, since comets themselves are regarded as gaseous bodies.

Meteorites seem to have no preference for any particular part of the earth's surface and they fall at any hour of day or night: the large meteors seem also to occur at any time of year, but the smaller meteors, the shooting stars, have periods of great abundance in August and November at intervals of many years. The most noteworthy of these "star showers" took place in 1833 and less notable ones occurred in 1866 and 1867: later appearances have been far less spectacular and it is believed that the influence of other planets may have diverted from its course the stream of small meteors through which the earth passed attracting to its atmosphere the bodies to which the display was due.

Naturally there are some popular beliefs in regard to meteors and some superstitions; that there are not more is probably due to the fact that so few of these visitors from space have in the past been seen to reach the earth. A pleasing belief is that a "shooting star" betokens the death of some one, usually a person of importance, and it is probable that this belief is of very ancient origin, dating back to the time when our

BÆTYL COINS

1 Seleucia in Syria c. 100 A.D.
2 " c. 200 A.D. } COPPER
3 " c. 300 A.D.

4 Amulet. Graeco-Roman GOLD

5 Emisa, 150 A.D.
6 Biblos, 200 A.D. } COPPER

7 Paphos in Cyprus, 70 A.D.
8 Mallos in Cilicia, 450 A.D.
9 " " " " "
10 " " " " " } SILVER

12 Emisa, Caracalla, Temple of Elagabal at Emisa
13 within conical stone of } COPPER
14 Elagabal

By courtesy of the American Numismatic Society

lives were influenced by stars and planets. Superstitions, inherited beliefs, are long-lived and die hard; centuries have passed since, according to Scripture, "The stars in their courses fought against Sisera," and we still upon occasion "thank our lucky stars" and speak of people as saturnine or jovial as the case may be.

A very attractive theory is that which assumes that when this earth of ours was taking shape out of chaos, after aeons of time, the germs of life were brought to it by some meteorite. This has the advantage of putting the origin of life so far away in space and time that we have no facts to interefere with any theories concerning it.

Perhaps the most famous of meteorites is the Black Stone of Mecca, the stone on which one legend has it that Jacob pillowed his head when he dreamed of the ladder reaching from earth to heaven whereon the angels ascended and descended; according to another version it was presented to Abraham by the angel Gabriel, for what purpose we are not told, while iconoclasts claim it to be a very very ancient pagan fetish long ago built into the walls of the Kaaba. We have no records telling of the Black Stone of the Kaaba, but from the writings of Livy, Plutarch and other early historians we know that meteorites were recognized and revered for centuries before the Christian Era and perhaps the excavations in the Roman Forum may some day bring to light one of these sacred stones. And yet, as we have seen, curiously enough the heavenly origin of meteorites was long denied by modern scientists.

As the ancients supposed the stars to be the residences of the gods, falling stars, or meteorites, were regarded as signifying the descent of a god, or the sending of his image to the earth. Hence they were received with divine honors, held sacred, and temples were erected for their reception. One of these stones is mentioned in the Acts when the "town clerk" said, "what man is there that knoweth not how that the city of the Ephesians is a worshipper of the goddess Diana and of the image that fell down from Jupiter?"[1] Not only were meteorites held to be sacred but medals and coins were struck in their honor or to commemorate their fall, a practice that endured for some six hundred years. It is interesting to note that while originally the effigies on these Bætyl coins bore some resemblance to the object they commemorated, as time went on the representation of these heaven-sent messengers became more and more human-like. Also, judging by the number of "tokens" struck (the collection of Dr. Brezina, of the Vienna Museum, numbers several hundred), one can not help feeling that then, as now, many objects were considered as falling stars that had no claim to that designation.

[1]Acts, XIX, 35.

The custom of placing objects in temples endured into the Christian Era and—in the shape of votive offerings—is still in vogue, so it is not surprising that the first meteorite actually seen to fall, the major portion of which is still preserved, was placed in a church where it remained for many years. This historic meteorite fell at Ensisheim, Alsace, between eleven and twleve of the morning of November 16, 1492, and a piece of it was included in the Ward-Coonley collection now incorporated in that of the Field Museum.

There are various popular errors in regard to meteorites, the most common being that they are intensely hot when they strike the earth, a very natural error since we see them traversing the air in a blaze of fire. So far from this being the case, they may be very cold, the Colby, Wisconsin, meteorite for instance was covered with frost when found shortly after its fall, although this occurred on July 4th. Why they are not hot is explained by Elihu Thomson in his consideration of Meteor Flight, which also explains some of the external features of meteorites:

"Innumerable meteoric bodies enter the earth's atmosphere daily from outside space, but few of these 'shooting stars' ever reach the earth's surface, because the atmosphere forms a sheath protecting us from them. If the velocity of a body entering the air is very high as compared with that of the earth, for example, 30 or 40 miles per second, the resistance offered by the air in front of it may be great enough to break it into fragments or crush it, while the high temperature given to the air thus compressed progressively melts and vaporizes the outer surface of the mass and then of its fragments. Thus, meteorites in their atmospheric flights are virtually subjected to a highly heated blast of strongly compressed air. Magnetic (the black) oxide of iron, which is formed by this burning of the metal in oxygen or air, is more fusible than iron itself, and it is swept back from the surface of a moving meteorite as fast as it is formed, much of it in spray or drops, but some of it in the state of vapor in the trail which marks the course of the body in the air. Melted, pear-shaped drops have, in fact, been observed in and falling from the train of slowly moving iron meteorites. If the meteoritic mass survives its passage through the air, it retains a thin, shiny, black skin over its surface composed of the iron oxide, or of glass containing iron oxide, in the case of the stony meteorites.

"An important point to be understood from the foregoing is that the energy appearing as heat is not transmitted to the body of the meteorite as such, but is dissipated in the air along with the oxide layer continuously formed, ripped off and left behind in the meteorite's path. Before the mass enters our atmosphere, its temperature is that of the space around it (absolute zero, —460° F.), and its flight through the air lasts for such

a short time, that the heat generated on the outside, though very intense, does not enter its interior. For comparison, when we turn a vigorous blast of hot gas, as a blowpipe flame, on a block of ice, the ice melts rapidly, the water on its surface is blown off as fast as formed, but what remains is always ice.

"If of somewhat rounded form, the meteorite may have rotated in the air, presenting all sides in succession to the corrosive wasting by combustion. If of irregular or elongated form, rotation would be checked, the body would advance in a position resulting from a balanced resistance around its center of mass and any further turning would depend on the rapid wastage of projections by fusion and combustion. There is, however, but little time, only a few seconds, at most, for readjustments of position to resistance encountered in the air. When there is little or no rotation, hollows or pits are dug in the forward side of a meteorite by the fierce air blast.

"The Willamette meteorite is a good example of a mass escaping fracture and dissipation, and it shows in marked manner the hollows, pits and grooves on the forward side, that which is now turned away from the center of the hall."

Another common mistake is that meteors pass, or fall, near the observer, when they are really miles away. A few years ago a fine meteor passed along the New England coast and observers south of Boston asserted that it dropped into the sea at the most a few miles distant; as a matter of fact it seems to have fallen many miles to the north of Cape Ann.

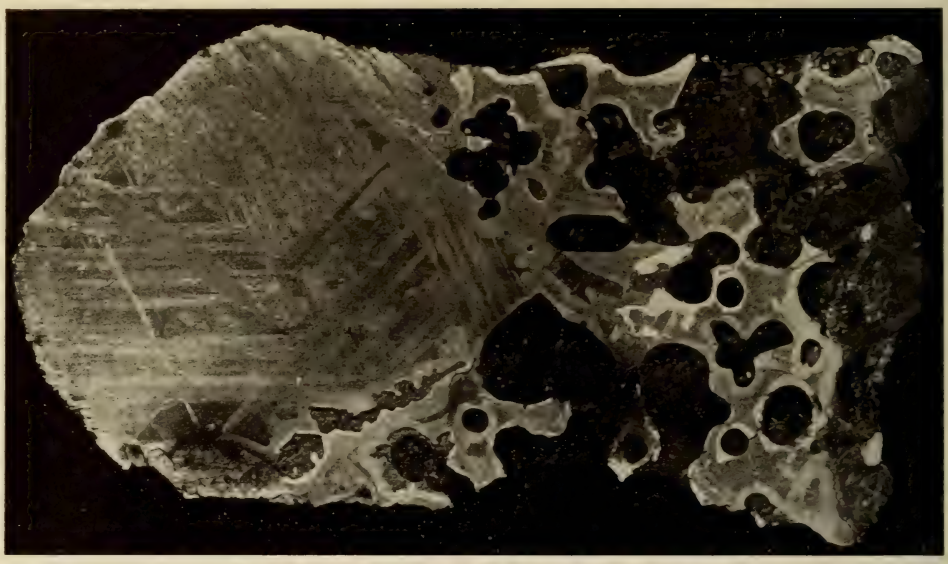
The death rate from meteorites is so low as to be negligible; while there have been a number of very narrow escapes, there is but one death actually on record, and that occurred in 1827, in India. Perhaps the narrowest of these escapes was when in 1847 a forty-pound meteorite crashed into a room in Braunau (Bohemia) in which three children were sleeping, covering them with dust and debris but leaving them unharmed.

The variety of objects sent to museums in the belief that they are meteors is astonishing, the most likely looking specimens usually proving to be pieces of furnace slag and the most unlikely including a "chunk" of cement which the sender declared had been seen to fall. Really very few meteorites have been seen to fall and later on been recovered, largely due to the point just noted that the distance of the fall is usually greatly underestimated.

Meteorites may be conveniently grouped in two classes, Siderites, or Iron Meteorites, and Aërolites, or Stony Meteorites. A third class, known as Siderolites, has been made to include forms that consist of both stone and iron but this can hardly be defined since such masses vary

from almost pure iron to almost pure stone. An important constituent of iron meteorites is nickel found in varying quantities and giving rise to the curious Widmanstätten figures shown on sections of polished and etched meteorites. This name was given in honor of Aloys Beck von Widmanstätt who first noted these figures in 1808.

While meteoric iron is soft, it is extremely tough and difficult to cut so that sawing a section from a meteorite is a slow process. In the

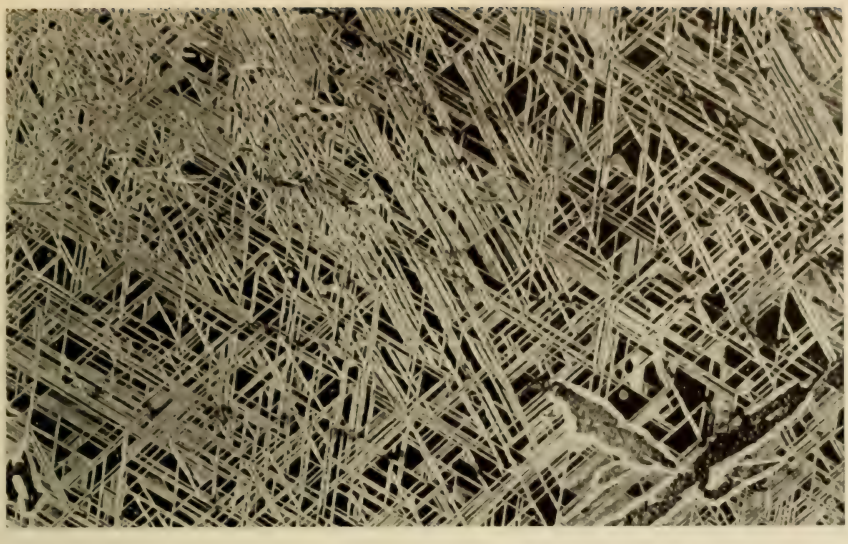


THE STRUCTURE OF METEORITES

A section of Brenham (Kansas) siderite (nickel iron) on the left, passing into siderolite (iron and stone) on the right. Note the broad Widmanstätten lines.

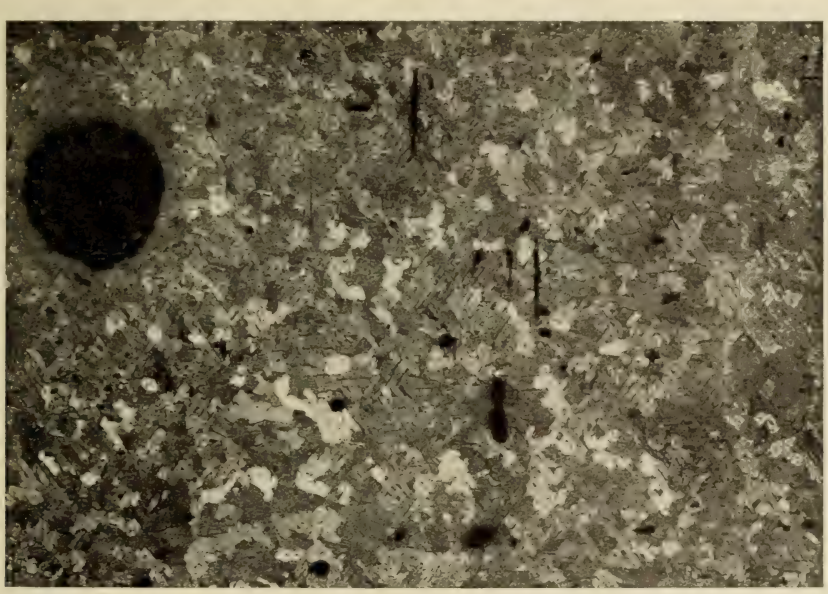
General Guide for 1914 and later, it has been stated that the occurrence of nickel in meteorites led to the adoption of a nickel-iron alloy for the armor for battleships, and as it is always difficult, and often impossible, to find any authority for an "it is said" it may be well to note that this statement came from Mr. Edwin E. Howell, who had much to do with meteorites, and who told the writer he had been informed that the extraordinary toughness of a meteorite which had been sawn at the Navy Yard, Washington, and the knowledge that it contained nickel, led to the trial and later adoption of the alloy for armor-plate.

Meteorites seem not to have attracted the attention of collectors or of museums until a comparatively recent date: there is no mention of any in the cabinet of Sir Hans Sloane, nor in the earlier guide to the



THE STRUCTURE OF METEORITES

Widmanstätten lines very clearly shown in a section of Carleton.



THE STRUCTURE OF METEORITES

A section of Willamette, showing its granular structure; the Widmanstätten lines are very faint.

British Museum (1762–1763) which was based on his collection. In 1926, the great collections had a combined representation of 820 falls. Fragments of the falls were to be found in five great museums, as follows:

Field Museum of Natural History (1925)	670 falls
British Museum (1922)	653 falls
Vienna Museum (1904)	560 falls
American Museum of Natural History (1925)	548 falls
U. S. National Museum (1925)	521 falls

The Field Museum owes its supremacy to the acquisition of the Ward-Coonley collection, brought together by Henry A. Ward, who devoted many years of time and travel to gathering the largest private collection of meteorites ever made. In making this collection Professor Ward visited and described the Bacubirito (Mexico) Meteorite, which he considered to be even larger than Ahnighito, having an estimated weight of 50 tons; however, this has never been weighed, and meteorites, like fish, are apt to lose in weighing, even Ahnighito, estimated at first to weigh 100 tons, and then at 50, shrank nearly 14 tons, when placed on the scales, and we suspect that should Bacubirito be tried in the balance it would be found wanting a number of the 50 tons ascribed to it. It required the labor of twenty-seven men to fully expose Bacubirito and it was then found that it rested on the solid rock, having apparently fallen before the soil had formed. The measurements of this great iron are 13′ 1″ long × 6′ 4″ × 5′ 4″. Ahnighito and Bacubirito shrink into insignificance compared with the iron reported to have been found in 1921 in the desert of Adrar, near Shingeti, Mauretania. This is said to be 300 feet in length, but as yet the report has not been verified. Another of Professor Ward's acquisitions was a piece of the Vermian iron preserved at Teheran, Persia. How to cut a piece from this was something of a problem; the arsenal at Teheran was equipped with a planer, but no motor, and the deficiency was supplied by running the planer back and forth by man power for several days.

The U. S. National Museum has labored under the handicap of limited appropriations and a belief that the national institution should pay more for a given object than any other, a belief that allowed these "others" to acquire various specimens at much less than the price originally asked. It is pleasant to record that of late years there is a growing recognition that, after all, the museum is a national institution and it is becoming more and more the recipient of valuable gifts.

So much for meteorites in general. A few words about some of the more remarkable specimens in the Museum collections are now in order. The American Museum of Natural History is the fortunate possessor of

the largest meteorite so far discovered (Ahnighito), and the largest, as well as the most interesting, found in the United States (Willamette). It also has a fine representation of the Canyon Diablo, popularly famous for containing diamonds, and a portion of the Long Island, Kansas, unique for showing a movement in the mass before it fell; so its collection may well claim to stand first as regards quality. The larger, more striking meteorites are displayed in Memorial Hall, the smaller, including many

TUCSON

An iron meteorite weighing 1400 pounds in the collection of the United States National Museum.

choice examples showing structure, are at present installed in the North Corridor, near the Auditorium.

AHNIGHITO, chief among meteorites, lay for many years on an island in Melville Bay, Greenland, and was secured by Peary in 1897 after unsuccessful attempts in the previous two years: the last of these, fortunately, left the "great iron" near the water's edge, on a rocky ledge that served as a pier. How it was finally placed aboard the "Hope," how the "Hope" smashed her way through the ice out of Melville Bay, and struggled through a gale to the lee of Wolstenholm Island where the

AHNIGHITO

The largest known meteorite, weight 36½ tons, brought from Greenland by Peary in 1897. Called the Tent by the Eskimo, christened Ahnighito by Marie Ahnighito Peary. Presented, together with the Woman and Dog, by Mrs. Morris K. Jesup, 1905.

THE WOMAN

One of the Cape York irons, weight 3000 pounds. In spite of the fact that she was guarded by the dog, the Eskimo pounded off fragments from which to make knives.

meteorite was lowered to a position of greater safety, is graphically told by Peary in "Northward Over the Great Ice." How it was christened Ahnighito by Marie Ahnighito Peary, then not quite a year old, just as the meteorite started on its last journey, is also told by Mrs. Peary in "The Snow Baby." So much bad weather attended the efforts to remove the big meteorite that it is small wonder that not only the Eskimo, but even some of the sailors regarded it with superstitious awe, but the spell was finally broken and no evil has accompanied it to its present resting place.

Associated with Ahnighito, which was known to the Eskimo as the Tent, though a few miles distant, were the smaller Dog and Woman, brought away by Peary in 1896, and now shown in its company.

Collectively these were appropriately called Saviksue, the great irons; and pieces of the Woman were laboriously hammered off by the Eskimo for knives, the worn-out hammer stones accumulated about it testifying to the time and patience expended in obtaining a few bits of the precious metal.

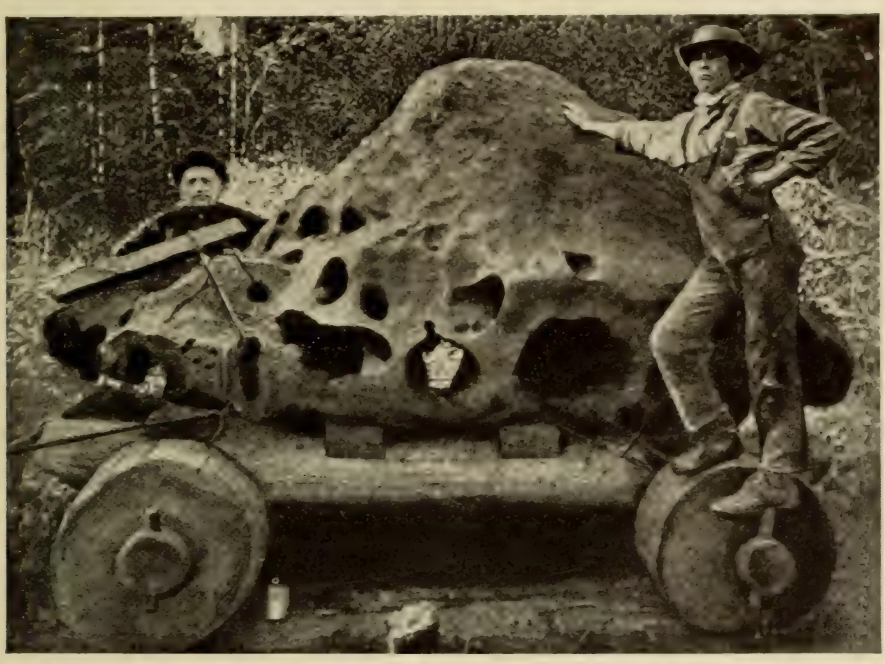
WILLAMETTE is not only the most extraordinary in appearance of any meteorite, and the largest that has been found in the United States,

THE DOG

One of the Cape York Meteorites, weight 1100 pounds. For centuries the Dog stood watch over the woman on an island in Melville Bay, Greenland.

but of interest for the struggle for its possession. It was found by two prospectors in the autumn of 1902 about 19 miles south of Portland, Oregon, on the land of the Portland Land Co. Having discovered that this was a meteorite, one of the prospectors, who lived about three quarters of a mile away, fashioned a rough but strong carriage to which with great skill and much labor he transferred the big mass of iron and with no other aid than that of his son, a horse, and a simple windlass, moved the meteorite to his own grounds. This took three months of hard work, for the ground was soft, and the meteorite heavy, the best day's work covered only fifty yards and sometimes the car was moved only fifteen feet.

When the Portland Land Company learned of their loss, and such a remarkable find could not be long unknown, they naturally entered suit for the recovery of their property and ultimately secured it, to the disappointment of Professor Ward who had hoped to make the Willamette the crowning glory of his collection. Instead, by the generosity of Mrs. William E. Dodge it now rests in the American Museum of Natural History where it arouses the interest of every visitor and where its history is daily read by many visitors. It is indeed remarkable, first for its size: it is ten feet long, and weighs fifteen and one half tons; and next



WILLAMETTE IN TRANSIT

for its appearance, being—on one side—deeply pitted with great hollows, large enough to hold a child. These are due to rusting as it lay in the ground, decomposition beginning with masses of troilite, one of the minerals peculiar to meteorites. The side next the wall is worn and slightly hollowed by the burning away of the surface as the meteor sped through the air.

Forest City is one of the few meteorites whose history is definitely known. As recorded by Dr. Hovey, "On Friday, May 2, 1890, at 5:15 P.M. a brilliant ball of fire shot across the sky from west to east in northern Iowa, its flight being accompanied by a noise likened to that of heavy

cannonading or of thunder, and by scintillations like those of fireworks. The meteoric light was dazzling even in the full daylight prevailing at the time and the noises, which were due to explosions, were heard throughout a district 200 miles in diameter. This meteor was the Forest City Meteorite. It burst when it was about 11 miles northeast of Forest City, Winnebago County, and the fragments, more than a thousand of which have been recovered, were scattered over an area about a mile wide and two miles long. Some of the pieces, each of which is a perfect little

FOREST CITY

meteorite, weigh as much as several pounds, but most of them are from a twentieth of an ounce up to twenty ounces. Forty-five fragments of this fall are in the American Museum of Natural History. The largest fragment is that shown, which weighs 75 pounds."

Holbrook (Arizona), a stony meteorite, fell as a shower of fragments, 2000 of which are in the collection of the American Museum of Natural History: they range in weight from $\frac{1}{90}$ of an ounce up of $14\frac{2}{3}$ pounds and have a collective weight of 485 pounds. The fall took place on July 12, 1912.

Canyon Diablo (Arizona) has already been noted, but it may be added that the diamonds it contains are mostly of minute or microscopic size and that it costs many, many times their value to recover them.

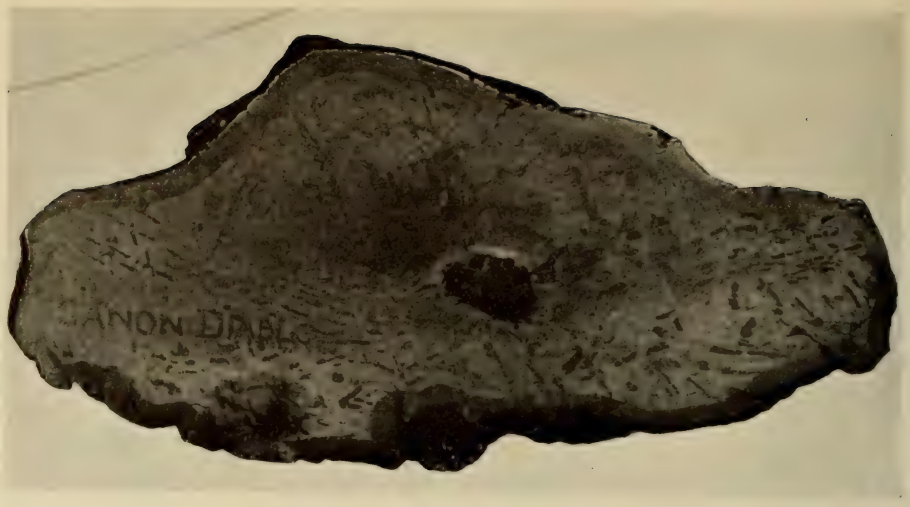
Long Island, found in Phillips County, Kansas, is noteworthy in several respects: in the first place it is unique in showing by its markings that some of the fragments into which it burst moved upon one another just before it fell; had it exploded when some distance above the earth these markings would have been burned away, leaving the usual crust of oxide. That it broke to pieces just before it struck is apparent because

CANYON DIABLO

A meteorite that contained minute diamonds; only one other similar specimen is known.

the 3000 pieces that have been recovered, having a combined weight of 1244 pounds, were found in a space of fifteen by twenty feet, the most compact "shower" known. It is also unique as being, in its total weight, the largest stony meteorite so far discovered.

Selma, a stony meteorite from Alabama, is believed to have fallen on July 20, 1898, though it was not found until March, 1906, the delay in its discovery being largely due to the fact that, as usually happens, it fell much farther from the observers than it was supposed to have done. If



SECTION OF CANYON DIABLO
A diamond was found in the black spot.

LONG ISLAND
The diagonal markings show that the fragments rubbed on one another just before they struck the earth.

SELMA

Weight 306 pounds, a large stony meteorite—aërolite— in the American Museum.

Long Island is collectively the largest stony meteorite, Selma, weighing 306 pounds, is one of the heaviest single stones in the United States, the largest known being a fragment of the Paragould (Arkansas) 1929 fall, weighing 820 pounds, now in the Field Museum of Natural History, Chicago.

These are the larger meteorites or those of more popular interest, but the hundreds of smaller specimens are important for the student, though aside from the time and place of their fall it requires careful chemical analysis and the aid of the microscope to gather the information they contain.

Hoba Wes, an iron known before 1921 and observed in situ on a farm near Grootfontein, southwest Africa, is probably the largest single meteoritic mass known. According to W. J. Luyten, 1929, the exposed portions of the rudely shaped rectangular block measure $9\times6\times4$ feet; estimates as to its weight range from 36 to 70 tons. Chemical analyses show that the nickel content ranges from 5 to 17 to 35 per cent, with 18 as a probable average. Widmänstatten figures are absent on etched surfaces. In this respect it is similar to some other south African irons of the Bethany fall. Up to 1931, the iron had been only partially exposed.

And here it may be well to say that the market prices for meteorites, save for those of exceptional size, are by no means so great as their finders sometimes suppose. They have never appealed to the private collector, so there is no keen competition for their possession, as there is for eggs of the Great Auk, to "boost" prices.

Finally—any day, or night, a meteorite may fall in your back yard, though the chances are many millions against it.

The American Museum collection includes meteorites from the countries, states and islands noted in the following list

METEORITE LOCALITY LIST

Alaska
Algeria
Anatolia
Arabia
Argentina
Australia
Austria
Azerbaijan
Belgium
Bolivia
Brazil
British Columbia
Chile
Colombia
Corsica
Costa Rica
Czecho-Slovakia
Denmark
East Africa
Ellesmereland
England
Esthonia
Finland
France
French West Africa
Germany
Greece
Greenland
Guatemala
Hawaiian Islands
Holland
Honduras
Hungary
India
Ireland
Italian
  Somaliland
Italy
Jamaica
Japan
Java
Latvia
Mauritius
Mexico
New South Wales
New Zealand
Norway
Ontario
Persia
Poland
Portugal
Queensland
Rumania
Russia
Saskatchewan
Siberia
South Africa
Spain
Sweden
Syria
Turkestan
United States
  Alabama
  Arizona
  Arkansas
  California
  Colorado
  Connecticut
  Georgia
  Idaho
  Indiana
  Iowa
  Kansas
  Kentucky
  Maine
  Maryland
  Michigan
  Minnesota
  Mississippi
  Missouri
  Montana
  Nebraska
  Nevada
  New Jersey
  New Mexico
  New York
  North Carolina
  North Dakota
  Ohio
  Oklahoma
  Oregon
  Pennsylvania
  South Carolina
  South Dakota
  Tennessee
  Texas
  Virginia
  West Virginia
  Wisconsin
  Wyoming
Victoria
West Africa
West Australia
Yugo-Slavia

FOR THE PEOPLE

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FOR SCIENCE

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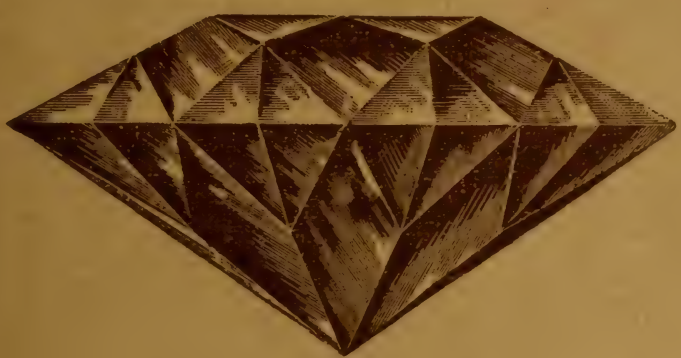
THE AMERICAN MUSEUM OF NATURAL HISTORY

THE ART OF THE LAPIDARY



By HERBERT P. WHITLOCK

GUIDE LEAFLET SERIES No. 65 DECEMBER, 1926

With its 444 perfectly proportioned facets this blue Topaz is a marvelous expression of the art of the lapidary. (Case VI)

THE ART OF THE LAPIDARY

BY

HERBERT P. WHITLOCK

Curator of Mineralogy

GUIDE LEAFLET NO. 65

THE AMERICAN MUSEUM OF NATURAL HISTORY

NEW YORK, DECEMBER, 1926

"And they were stronger hands than mine
That digged the Ruby from the earth
More cunning brains that made it worth
The large desire of a King."

—*Rudyard Kipling*

The Art of the Lapidary

INTRODUCTION

Although a gem mineral in the rough always exhibits certain qualities, which, to a discerning eye, give promise of its possibilities as a gem, it is through the shaping and facetting of these bits of mineral that their real charm is developed. Gem stones are, in general, cut

1.—To bring out beauties of color.

2.—To adapt them to jewelry forms.

3.—To develop the scintillating reflections from the interior of the stone by making use of the principles of refraction of light.

The first two of these considerations are too obvious to require more than a word of explanation. The surface of a transparent uncut gem stone may be compared to the surface of a body of water rendered rough and broken by waves and ripples. It is only when such a surface has been rendered smooth that we are enabled to look down into the depths below and see to best advantage its color. The stones which embellish a piece of jewelry must have a regularity of outline and a symmetry in the disposal of their planes and angles in order to best please the eye.

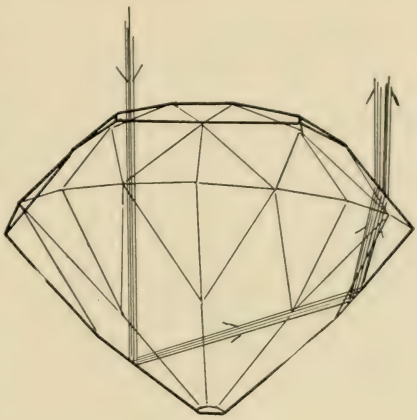


Figure 1

The third reason for the cutting of planes or facets on transparent gem stones needs rather more explanation. We have no doubt many times had occasion to admire the brilliant flashes of light reflected back from the interior of a diamond without realizing how this effect was produced, indeed the reason why a diamond glistens is to most of us a deep mystery. When we put a spoon in a glass of water and hold it above the level of the eye we can see a reflection of the submerged part of the spoon from the under side of the surface of the water which acts as a mirror. Now the light that falls on the upper surface of a correctly cut diamond is reflected back to the eye from the smooth *under* surfaces of the stone in just the same way that the spoon is reflected from the surface of the water in the glass. In figure 1 the paths traversed by some of these rays of light are shown, and it will be seen that they are reflected from the angular sides of the diamond in much the same way that a billiard ball is deflected from

the cushions of a billard table. It is important that the facets should have the correct inclination to one another in order that no light should "leak out" from the under side of the stone, and it is here that the lapidary, that is the person who cuts the stone, must take into account its *index of refraction.* By this we mean the amount of bending that light undergoes when it enters obliquely one substance such as water or diamond from another such as air. Because the refraction of diamond is so high, light having passed through it, must "hit" a surface from the inside much more squarely than would be the case with another substance, such as glass, in order to pass back into air. To insure that all the light that falls on the upper surface of a cut diamond shall be reflectedback we have only to proportion the stone so that the facets of the under side will have

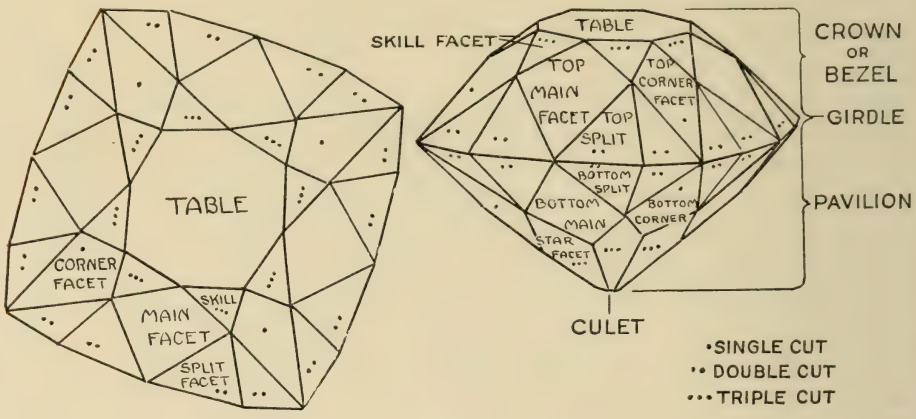


Figure 2

the proper inclination and our diamond will glisten like a star. But a diamond does something more to light than merely reflect it back, it also tends to split up the white light into the colors of the spectrum, so that mixed with the brilliant flashes of white light we also have gleams of the all colors of the rainbow sent back to the eye from our cut stone, which is very properly called a brilliant.

The upper part of a brilliant is called the *crown* or *bezel* and the lower part is known as the *pavilion,* the line separating the crown from the pavilion and which marks the widest part of the stone is the *girdle.* The size of the girdle constitutes the *spread* of the stone and the crown and pavilion taken together constitute its *depth.* There are also special names given to the various kinds of facets and these are given in diagram in Figure 2.

HOW GEMS ARE CUT

When we come to consider the methods and tools of gem cutting, we encounter a sharply defined boundry between these methods and tools as applied to the cutting of diamonds and those used in the fashioning of other and softer gems. This difference of treatment is, imposed in the case of diamond by the special difficulty to be met in grinding and polishing facets on such an exceedingly hard substance.

We will then begin our little excursion into the side of gem knowledge that deals with the way gem stones are treated at the hands of the lapidary by following a diamond on its journey from the mine to the jeweler and seeing for ourselves just what happens to it. When the diamonds are taken out of the mine, not by any means all of them are clear and colorless, as self respecting diamonds should be: indeed only about 25 per cent of the stones found are without some faint color. Of the remainder about one third are of a light shade of violet, yellow or brown, and are known as "off color" stones. The remainder roughly one half of the total find, are more or less deeply colored and are consequently of no value for jewelry although still usable as diamond dust for cutting and polishing and also for the cutting edges or facings for rock drills. So we find that at the beginning of its travels the diamond is introduced to the sorter. The sorter is a kind of a super-expert on diamonds whose eye has been trained through years of practice to detect the slightest variations in the color of diamonds, and to find flaws in stones with an ease which is little less than uncanny. Safeguarded behind a heavy metal screen, the diamond appraiser sits with a pile of rough stones before him, judging each stone and assigning it to its proper heap.

The first consideration in sorting diamonds is the adaptability of the stone for cutting. Let us assume that the stone whose travels we are following is sorted into the grade known as "close goods" comprising, complete, flawless crystals from which fair-sized brilliants can be cut, to use the trade term, "made." These usually have eight sides or faces, triangular in shape. Next comes a resorting of the "close goods" into eight grades, ranging from blue-white, which comprises the stones of finest quality, to yellow and brown crystals, which are so badly off-color as to be unfit for gems. If our stone has passed the critical test of the sorter and has been placed in one of the higher grades, it is weighed wrapped up in a parcel with others of its kind, a price per carat is assigned to it, and it is sold to a diamond dealer, and ultimately finds its way to the workshop of the diamond polisher. Here at the hands of a highly skilled workman, it is destined to be turned into a gem fit to grace beauty or proclaim opulence.

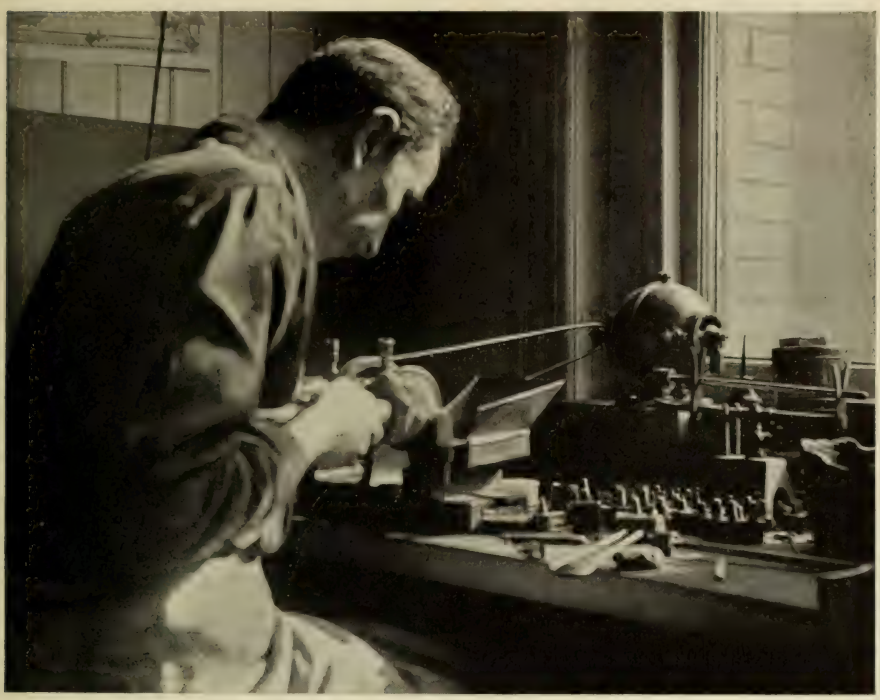
Much of this work is done in Holland and especially in Amsterdam which since the Fifteenth Century has been famous for this industry, which is in reality an art, but there are, nevertheless, a number of shops in operation in New York and in other American Cities. Like many other operators who depend for their success on a high degree of manual skill, the diamond cutter uses few tools, and these are relatively primitive and have changed but little since the days of Louis de Bequem, who cut

Like a skilled surgeon the diamond lapidary performs the delicate operation which is known as "slitting." Just the right amount of the stone, no more and no less, must be split away. The intent expression on the face of the operator bears witness to the momentous effect of the slight blow he is about to strike on the steel knife edge which he holds in his left hand.

diamonds as early as 1475. The lapidary trained in his art depends, like the violin player on the delicacy of his touch, and like the painter on the accuracy of his eye. In general he does not employ complex mechanical devices to aid him in his difficult task.

The surface irregularities, which are often present on diamonds of even the highest quality must be first split away from the stone, which breaks naturally along smooth, even surfaces parallel to the natural faces of an octahedron. Superficial flaws, that is incipient cracks, and

dark patches or "carbons" must also be eliminated in this way. Sometimes these occur deep in the center of an otherwise perfect crystal, in which case the diamond is divided *through* the imperfection and made into two or more cut stones. To accomplish this cleavage, which is known as "slitting," our diamond is firmly cemented to the end of a wooden stick which, in turn, is supported firmly in an upright position by wedging it



Even the refuse from this operation is valuable and must be saved. As the lapidary rough-shapes his diamonds, rubbing or "bruting" the one on the end of the long stick which he holds under his right arm, against the other on the rapidly turning spindle which is driven by the belt, the dust and fine fragments fall into the little box shown in the centre of the picture. Only the protruding end of the stick is visible in the illustration.

into a hole in the working bench. The diamond lapidary now makes a deep scratch in just the right place upon the surface of the diamond crystal, using for this purpose the sharp corner of a diamond fragment. A knife edge is then held in the correct position on the scratch, and a sharp blow with a light tool struck on the back of the knife edge suffices to remove the undesirable flake, leaving the surface bright and very smooth.

Sometimes, when the stone is large, it is of advantage to saw it into two or more pieces so as to save as much as possible of the weight in cut diamonds. This is accomplished with a thin disk of bronze, about four inches in diameter, revolving very rapidly and having its edge charged with diamond dust at the beginning of the sawing. As the saw bites into

The tools of the diamond lapidary's art are very simple. The little metal cut or "dop," in which the diamond is being placed, as well as the wooden holder which carries it, are of exactly the same shape as those used by the diamond cutters of a hundred years ago.

the stone, it keeps recharging itself with the diamond sawdust. It takes many hours for this little "buzz saw" to eat its way through half an inch of diamond, but the finished product is so valuable that a day or so of labor makes little impression on the cost sheet.

The rough shaping of the diamond is done through an operation called "bruting," which consists of wearing away the corners by rubbing

one stone against another. Formerly this was strictly a manual process, the two diamonds being mounted on sticks held in either hand by the lapidary. Even into the ancient and conservative art of diamond cutting, however, some mechanical improvements have made their way, and now in most of the shops a rapidly twirling spindle takes the place of one of the hand sticks. The remaining stick has grown in length to suit the modern method. It is now about two feet long and can be firmly grasped

The actual cutting of the facets on the diamond, known as "polishing," calls for the highest expression of the diamond lapidary's art. The stems of the "dops," which bear the diamonds, must be adjusted in the "tongs" with fine nicety. Here again the form of the tools has not changed in a century. The iron "tongs," the wheel and its spindle (shown in the centre of this picture), even the metal pegs against which the tongs are kept in place on the wheel, are the same as those used in Amsterdam and Antwerp in 1821.

with both hands and held in a rest so that the diamond it bears at its end can be rubbed against its fellow, which is spinning in front of it.

Having in this manner rough-shaped our diamond, we now come to the finishing operation, the producing of the facets which give brilliancy and sparkle to it, an operation which is technically known as polishing. The holder of the stone during the polishing consists of a small metal cup on a long stem, which is called a "dop" and much resembles a tulip,

which famous Dutch flower may have suggested its shape. A solder composed of one part tin and three parts lead is placed in the dop and heated until soft. The diamond is then embedded in the solder with the portion of the stone on which the desired facets are to be cut placed uppermost. When the diamond has been properly adjusted in the dop, it is plunged in cold water to cool and harden the solder. Such drastic treatment would cause less aristocratic stones promptly to fly to pieces, but not so with the diamond; the high heat conductively of this remarkable mineral permits to to submit to the sudden change of temperature without there resulting in it even the slightest flaw.

The dop is now fastened by means of its stem in a heavy iron arm, called the tongs, in such a way as to bring the position of the facet to be cut exactly undermost when it is placed in contact with the polishing wheel or "skeep." It is here that the skill and training of the diamond cutter is exercised to its fullest, for the tilt or inclination of the various facets, the one to the other depends on the position of the dop in the tongs and on just how much the stem of the former is bent to the one side or to the other.

The "skeep" is made of soft iron and turns horizontally at the rate of about 2500 revolutions a minute. Diamond dust, mixed with olive oil, is fed to this wheel and the diamond is held in contact with it by the weight of the tongs aided by slabs of lead placed upon the latter. Much care has to be taken to keep the skeep perfectly balanced so that it will revolve without the slightest rocking motion, because this would materially interfere with the even smoothness necessary to the production of a finely polished surface. Several hours are required to cut one facet, then the dop is readjusted for another one, or the stone is removed and reset in the dop, and so on until all of the fifty-eight little faces in which lie the secret of the brilliancy of the jewel are produced.

To appreciate the exquisite skill and infinite patience involved in this apparently simple process we have only to look at the gem on our finger sending forth its magical fires, and to note the symmetry and regularity of shape of each of its tiny glittering sides. And when we remember that to produce these rainbow-like rays each must have exactly the right tilt with respect to its neighbors, we realize that a cut diamond is not only a wonderful product of nature but a marvelous work of art.

The cutting of the softer gem stones is not nearly so laborious an undertaking as the cutting of diamonds. Not only is diamond harder than any other substance known, but it is very much harder than the corundum gem stones that follow next after it in hardness. So it is that we find the tools and methods applied to the softer gem stones at once simpler and more highly manual.

The native lapidaries of India and Ceylon have reduced the apparatus of this phase of gem cutting to its lowest terms. Such a native artisan seated on his carpet in the bazaar, turns the stone lap in front of him by the primative means of a bow, the string of which is wrapped around the axis of his stone grinding wheel. By his side is a bowl containing the emery he uses as a grinding medium mixed to the right consistancy with water, and his left hand is the only holder for the gem stone that he is manipulating. This is indeed reducing the tools of gem cutting to an absolute minimum, and emphasizing in a striking way the essentials of this art.

These essentials are then:—

1.—A rapidly revolving wheel, the flat surface of which is of just the proper roughness for retaining the powdered abrasive with which the cutting of the smooth facets of a gem stone is accomplished. This wheel is usually termed a lap.

2.—A holder, corresponding to the dop used in diamond polishing, but in this instance made of wood and resembling in size and shape an old-fashioned pen holder.

3.—An abrasive substance of a greater degree of hardness than the gem stone to be cut which is fed to the lap as a powder mixed with water to a more or less thin paste. For the final polishing the abrasive is fed dry to a wooden or cloth covered lap.

Gem stones are first sawed or "slit" by means of a thin disk of relatively soft metal whose edge is slightly indented with a knife blade for its entire circumference. Diamond dust mixed to a paste with water, is fed to this circular saw, and lodging in the indentations of the circumference constitutes the cutting edge. The process of slitting for colored stones is very much more rapidly accomplished than the corresponding operation for diamonds and, except in the case of valuable gem stones such as rubies and sapphires, no great amount of care is taken to conserve the chips taken off.

After a suitable piece, free from flaws and other blemishes, and of convenient proportions, has been sawed from the crystal or rough fragment of gem material, this piece is usually cemented to the end of a wooden holder for the rough shaping which corresponds to the "blocking out" of a painting. This is done against an emery or carborundum wheel, resembling a small grindstone and revolving on a horizontal axis. If the stone is to be given a "cabochon" or rounded cutting like an opal or a cat's eye, it is finished on this wheel and polished on a similar one of softer material charged with rouge or putty powder. If, however, the stone is to be facetted, the real skill and judgment of the lapidary is

called into play. The rough shaped stone is attached with cement to the blunt end of a wooden holder, called the stick, which is about 8 or 10 inches long and which is pointed at its free end. The position of the stone when fastened to the stick is so chosen that the table facet when cut will be at right angles to the latter and it is embedded in the cement up to the point where the prospective girdle will encircle it.

The grinding lap, which is made of gun metal, copper or lead, depending on the hardness of the stone to be facetted, is mounted so as to revolve in a horizontal plane like the skeep used in polishing diamonds,

Extremely simple are the tools and methods employed by the lapidary working in stones other than diamonds. The wheel or lap, a stick to hold the gem, a notched peg, seen behind his hand and his own supreme manual skill alone suffice him.

and the speed at which its surface travels *against* the stone can be manipulated with great nicety by moving the latter nearer to or farther from the center. Having charged his lap with the appropriate abrasive, emery or corborundum the lapidary now places the stone upon its surface and holding the stick in a vertical position grinds the table facet to its correct proportion with respect to the design of facets which he has in mind.

The next step is to cut the first of the main facets of the crown, which of course necessitates the holding of the stick at just the right angle to the surface of the wheel, and as a rough guide the lapidary is here aided by a device called the "jamb peg" mounted at the side of the lap and pivoted

so as to swing out over it. The jamb peg is shaped somewhat like an elongated peg top and is furnished with a series of shallow indentations at regular intervals from top to bottom, so that by placing the sharpened end of the stick in one of these a constant angle between the stick and the surface of the lap can be maintained. Having cut the first of the main facets of the crown to the right depth, the lapidary now turns the stick through just the right arc of a circle to bring the next facet to bear on the surface of the lap and using the same hole in the jamb peg cuts this also to the correct depth constantly inspecting his work and judging the fine points of inclination and proportion of the facets by eye. But since he can not see what is taking place while the stone is in contact with the lap, he must here depend on a highly developed sense of touch. Just as the finger of a violinist flies unerringly to the precise spot on the neck of his instrument to produce a given note, so the trained touch of the lapidary guiding the stick that holds his gem upon the wheel finds almost by instinct the correct angle for the stone to come in contact with the grinding surface to produce the result he desires.

One after the other the main, split and skill facets are cut and then the stone goes to the polisher who, working in the same way but on a lap having a softer and finer surface, and using a finer abrasive, removes the slight scratches from the facets, polishes them to a finished brilliancy and incidentally corrects any slight irregularity in their proportion. Because of this last consideration it follows that the polisher must be a master in his craft.

The crown or upper half of the stone having thus been completed it is now removed from the stick, cleaned and again mounted in cement, but this time with the lower half exposed on the end of the stick. The process of cutting and polishing is now repeated for the pavilion facets and the stone is finished.

THE FORMS IN WHICH GEMS ARE CUT

THE EVOLUTION OF THE BRILLIANT CUT

The history of gem cutting, insofar as it touches the modern art of the lapidary, may be said to begin with the introduction of diamonds as personal ornaments into Europe about the 15th century. It is perfectly true that precious stones were worn upon the person of men and women at a period which carries us well back into prehistoric times, and it is possible to trace a certain rough fashioning in even the most antique of these. But, aside from the question of whether the early gem artifacts were worn for purely esthetic reasons; or, as is more probable, for charms endowed with a certain occult potency, the fact remains that up to a comparatively late period no attempt was made in shaping a gem to do more than adapt its outline to the form of setting designed for it, and to round off its corners and irregularities so that its color might be seen to the best advantage.

In tracing the development of gem cutting in general, we are led inevitably for a point of departure to the forms first produced in the cutting of diamonds, because these early diamond cuttings impressed their character and symmetry not only upon later developed forms of cutting adapted to diamonds but to the subsequent development of forms of cutting among all the other transparent gem stones.

We have the authority of O. M. Dalton in the Catalogue of Finger Ring in the British Museum for the statement that previous to Louis de Bequem, that is prior to the latter half of the 15th century, four of the eight faces of octahedral diamond crystals were sometimes polished and the stone set with the polished pyramid projecting while the unpolished portion of the stone was imbedded in the setting. The next step in advance of this very obvious and primitive facetting was to brut two diamond crystals together until the operator had worn away one of the points of the octahedron into a square facet, corresponding to a table in the modern brilliant, and similarly worn a smaller facet on the opposite point corresponding to the culet. This earliest of diamond cutting is shown in Figure 3. Frequently the culet was omitted and the table was developed to even a smaller extent than shown. We have reason to believe that this modified point cut persisted at least into the 17th century inasmuch as a ring dating from this period in the British Museum collection is set with a diamond cut in this way.

Aside from the fact that the modified point cutting utilized the maximum spread and a large proportion of the maximum weight of a given stone, the square girdle produced a certain awkwardness which, sub-

sequently led to the modifying of this form by the cutting away of the corner edges both in the crown and the pavilion and the production of an octagonal girdle.

As a finished expression of the diamond cutters art this form of cutting, which is shown in Fig. 4, and which is sometimes called single-

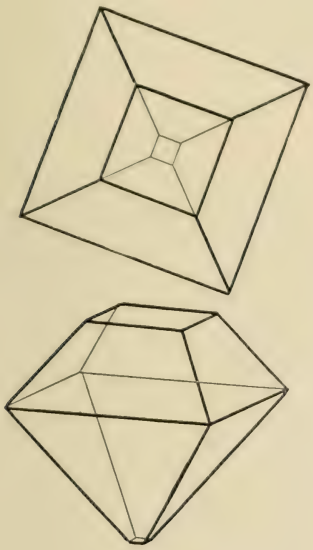


Figure 3

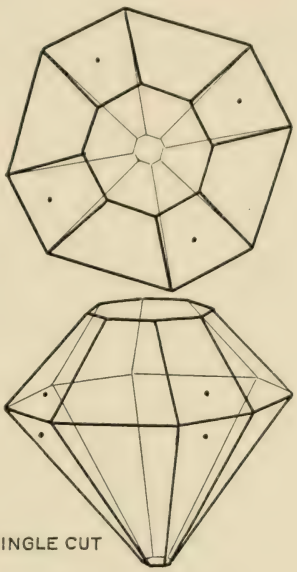


Figure 4

cut, has long been obsolete; it is, however, interesting to note that in the evolution of a modern brilliant cut, the diamond crystal or cleaved piece passes through both of the preceding forms as its initial stages before the split, star and skill facets are produced. It would seem fair then to consider both of these cuttings as old forms of brilliant cut.[1]

About the middle of the 17th century a development of the two previous forms of cutting into what has been variously called the square cut brilliants, single-cut brilliants,[2] or double cut brilliants,[3] took place. The first of these forms, Fig. 5 which we will call the square cut brilliant, retains the original square table of Fig. 3; the top main facet of a single cut starting from the corner of the table making with the single cut an octagonal girdle the corners of which are taken off with the corner facets of a double cut starting from the same point. The main and corner facets are repeated in the pavilion starting from a point on the edge

[1]See W. R. Catelle, The Diamond, Plate V, Figs. 1 and 2.
[2]Emanuel.
[3]Bauer.

corresponding to the corner of the table. This gives a brilliant of 34 facets not without a certain amount of symmetry, particularly in the crown.

The English square-cut brilliant, or old English star-cut brilliant, Fig. 6, is derived as in Fig. 4, and with double cut corner facets developed as in the previous cutting. This gives a brilliant of 30 facets with an octagonal table and a rather more symmetrical grouping of the facets of the crown than any of the preceding cuttings. A somewhat later development of the double cut brilliant is shown in Fig. 7. This is the connecting link between the single cut brilliant of Fig. 4 and the various forms of the triple cut brilliant which will be presently discussed; the edges between the main facets of the single cut being partly replaced in crown and pavilion each by two corner facets. This gives a brilliant of 50 facets with much the same outline of the girdle as has the Brazilian cut or Old Mine cut (Fig. 9).

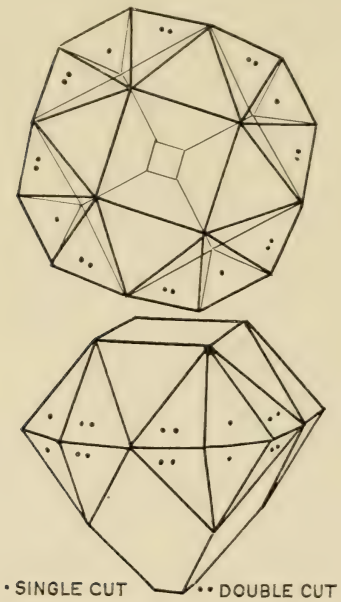


Figure 5

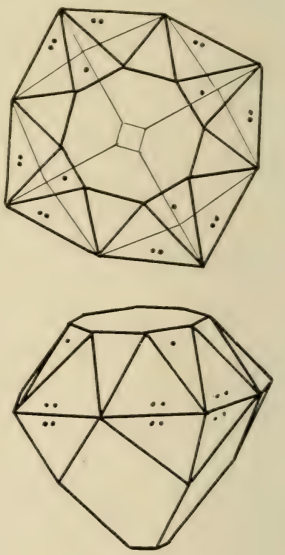


Figure 6

What the square-cut brilliants following the lines of the basic octahedron failed to do was accomplished with the introduction of the triple-cut brilliant toward the end of the 17th century and the beginning of cutting for brilliancy and weight rather than for weight alone. Three variations of the triple cut brilliant are of sufficient importance to be here considered.

The English Round Cut Brilliant of which an excellent description with relative proportions is to be found in Emanuel's Diamonds and Precious Stones, was apparently in vogue in England in the middle of the 19th century. This variation of the triple cut brilliant (Fig. 8) differs from the American brilliant of today only in the relative proportions of its essential parts. In it the angles of the octahedron were deviated from to produce a stone of depth rather than spread, the "lumpy" aspect of the cutting being the result of making the diameter of the girdle equal the

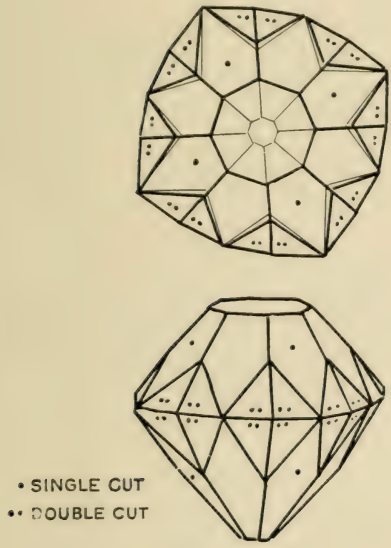


Figure 7

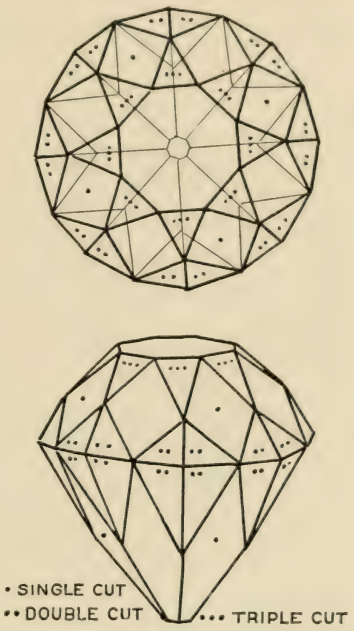


Figure 8

total depth. The number of facets were increased to 58 by the addition of the skill facets in the crown, a change which not only added to the symmetry of the exposed portion of the cutting but increased the surface reflections. The essential innovation, however, lay in the altering of the angles of the crown and pavilion main facets to totally reflect back a large proportion of the light falling directly on the crown, these reflections materially adding to the brilliancy of the cutting. It is evident that the theory of this cutting necessitates rather a high crown with a relatively small table and that some sacrifice is made of the spread of the stone so that for a given weight a stone of relatively small spread but considerable brilliancy is obtained.

The tendency to retain the girdle outline of the old square cut brilliants found expression in the Brazilian cut brilliant or Old Mine cut, which is shown in Fig. 9, and which was very much in vogue during the last century at a period when Brazil was producing most of the world's diamonds. In the example shown, the angles between the main facets of the crown and pavilion approach more nearly in average to the ideal angle (80°-85°) of the modern brilliant than in the English round cut brilliant, where this angle is over rather than under 90°. The result is a

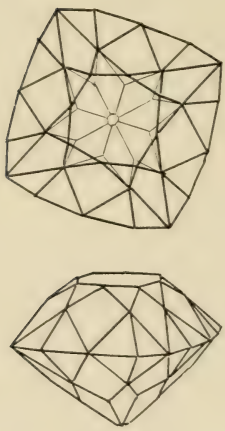


Figure 9

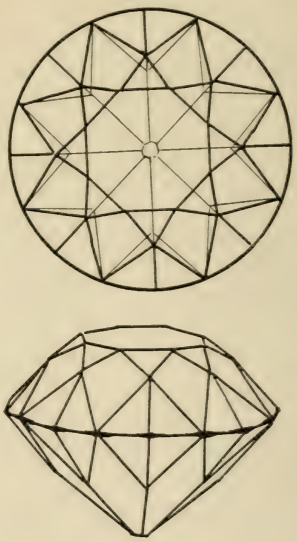


Figure 10

cutting of better because less "lumpy" proportions and one in which thinner stones could be cut to better advantage.

The final stage in the evolution of an ideal brilliant cut takes the form of the American cut brilliant shown in Fig. 10. This cutting combines the most satisfactory angles of the Old Mine cut in a brilliant with a round girdle, and although, undoubtedly some of the weight of the uncut stone is sacrificed to brilliancy and prismatic reflections a considerable spread compared with the weight of the cut stone is reached.

VARIATIONS OF THE BRILLIANT CUT

In tracing the evolution of the brilliant cut from its earliest and most primitive form down to the highly developed brilliant of our own day, we followed, as it were, the main line of evolution leading to the cutting most adaptable to stones of medium weight and general use. It must be

clearly borne in mind, however, that in the course of this development forms of gem cuttings have sprung from the main line of advance at many points, some of these having achieved only a transient popularity in the past, and some representing variations which are still in use for stones adapted to certain settings. To anyone familiar with the great diversity of these variants from the well known brilliant form of cutting, the futility of attempting anything in the nature of a classification will be quite patent. In some instances, as in the case of the table cut, the variation is mainly one of proportion, while in other cases the forms of cutting are combinations of brilliant and step cut. For convenience in arranging the data collected, it has been thought best to roughly divide the varia-

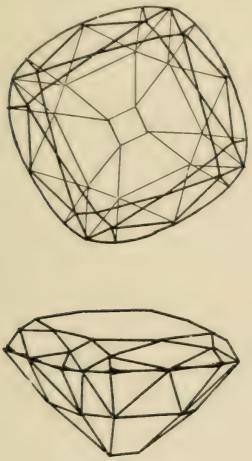


Figure 11

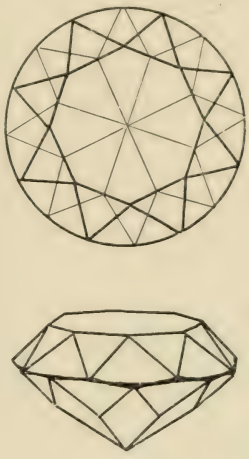


Figure 12

tions of the brilliant into three groups, based partly on the adaptability of the cutting to jewelry forms. Grouped in this way we have:

(a) Cuttings with symmetrical or rounded girdles.

(b) The commoner forms of fancy cuttings.

(c) Unusual forms of fancy cuttings.

The first of these groups include stones adapted to solitare ring settings, for the centers of clusters, and in fact for every form of jewelry setting where a round, square or six-sided stone is required.

Conspicuous among cuttings of this group is the square brilliant, a notable example of which is to be found in the Cullianan IV diamond, shown in Fig. 11. Although of much the same girdle outline as the typical Brazilian cut, exemplified in the Regent diamond, this cutting differs widely in proportion from the older forms; the crown is shallow with a broad table, and a considerable mass of the stone lies below the

girdle. The main facets of the pavilion were doubled, bringing the number of facets up to 66 and giving to the culet end of the stone the appearance of a step cut treatment.

The round double-cut brilliant shown in Fig. 12 and known as the table cut, represents a degree of simplicity of cutting which strongly suggests the old English star-cut brilliant from which it was possibly derived. The table cut has 33 facets and is characterized by a broad spread compared to the depth, and a shallow crown with a broad table. In the example studied for Fig. 12, the proportion of spread to depth was 2 to 1, and the depth of the crown was about one-third the total depth. Thin

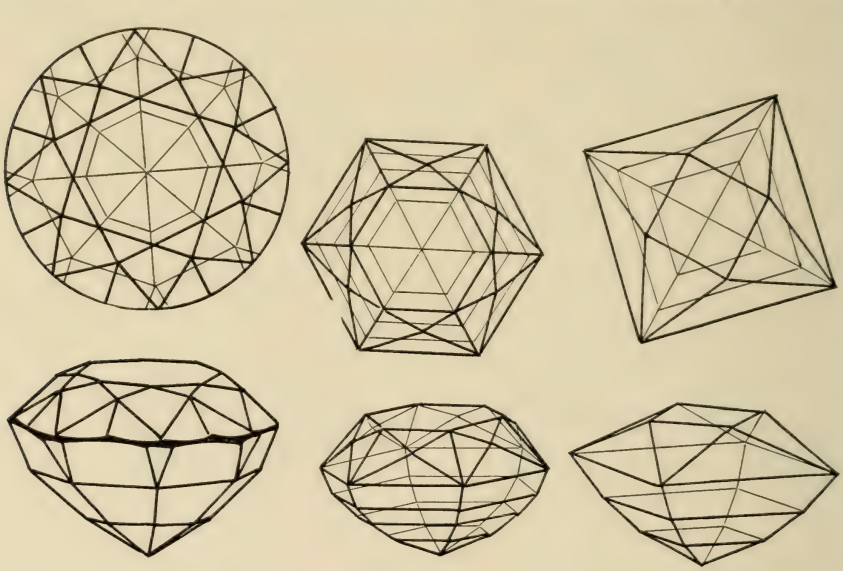


Figure 13 Figure 14 Figure 15

diamonds were formerly made in this cut, which has little or no advantage other than a high proportion of spread to weight

An extremely popular cutting for sapphires, rubies and the deeper colored semipreicous stones is the combination brilliant-step cut. An example, studied from a blue synthetic sapphire, is shown in Fig. 13. This variation of the brilliant has a rather low crown, cut with the conventional 33 facets, and a deep pavilion of three tiers of stepped facets. The girdle-bottom main facets are shaped to the circular girdle by single triangular corner facets, as shown in the figure. For colored stones of high index of refraction the combination cutting is very effective, as it brings out both the fire and the color of the gem, but like all forms involving step cutting, it requires that the proportions and slope of the pavilion facets should be carefully studied.

The six-sided cutting shown in Fig. 14 although formerly used to a limited extent for diamonds, has now almost entirely given way before the various forms of unmodified step cut. This cutting is in reality a variation of step rather than in any sense a form of brilliant cut; it is introduced here, however, because the use of corner facets in the crown allies it to an extent with the latter group. In the example shown in the figure the cutting produced rather a "lumpy" stone in which about one-third of the total depth lay above the girdle. Diamonds made in this cutting are often met with in old-fashioned settings, and there is no doubt that they possess a certain quaint charm; but unless very carefully proportioned much of the brilliancy of the stone is lost.

The French cut brilliant, illustrated in Fig. 15 is principally used for small rubies, emeralds and sapphires when it is necessary to set these in a row for a bar pin or similar piece of jewelry. In this case of "calibre" cutting the square girdles of all of the stones constituting the setting must of course be made exactly the same size. For a small circlet, as in the instance of a diamond encircled by calibre-cut sapphires, the small stones are cut with a girdle which is slightly keystone-shaped to accommodate the curve of the circle. Like the preceding this cutting is closely allied in make to the step cut, being essentially a step cut with star facets in the crown.

In dealing with the great variety of fancy cuttings which are more or less derived from the brilliant cut, the difficulties in the way of arriving at anything approaching an adequate basis of classification are appreciably more than those met with in dealing with the group of cuttings with symmetrical or round girdles. At least in these latter we were guided by the outline of the stone and by the fact that most of the cuttings of this type were designed for setting in solitaire rings or for the centers or encircling elements or clusters. We now come to a group of cuttings of excentric girdle outlines, distorted from the round and with the brilliant cut crown, which alone ties them to the basis from which they are derived, pulled this way and that until the possible shapes producible as fancy cuttings seem endless. Another point of differentiation between this and the group previously discussed, is that in the case of the fancy cuttings the stones are mostly adapted to settings other than rings, and that the cuttings are to a large extent used for the making of stones other than diamonds. A notable exception to both of these latter characterizations is that of the marquise cutting which is used principally for diamonds and is almost universally set as a ring stone. The marquise was introduced as a cutting for diamonds early in the last decade of the XIX century when popular taste in ring stones created a demand for a long narrow cutting intended to be set with the long axis parallel to the finger joints.

A typical example of a marquise cut diamond is to be found in No. VII of the Cullinan cuttings, which weighs about 9½ carats. Fig. 16 was studied from a model of this stone, and represents an average proportion between length and breadth of girdle outline which varies to a very considerable extent in this as in most of the other fancy cuttings. The 58 facets which constitute the "make" of the marquise correspond in relative position, facet for facet, with those of the round brilliant, the obvious distortion in shape of the facets being occasioned by the lengthening of one diameter of the type cutting. The broken arcs which outline the table are rendered more nearly circular by decreasing the size of the skill facets, so that instead of meeting corner to corner around the table their edges with the table are alternated with edges of the top main facets.

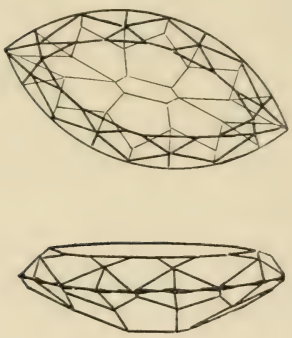


Figure 16

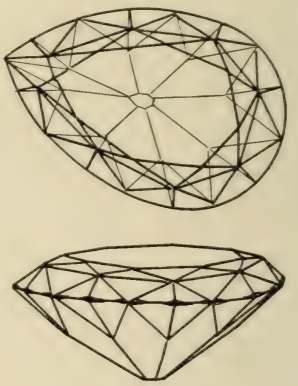


Figure 17

The pendent cut, illustrated in Fig. 17 is used for a great variety of precious and semi-precious stones. The example shown was studied from a model of the No. 111 Cullinan diamond, and may be taken as an average in proportion of length to breadth between the very broad pendent shapes, as exampled in the Cullinan I diamond and the very long slender pendents cut from small chrysoberyls, tourmalines or aquamarines. Whereas in the case of the marquise the variation from the round brilliant was produced by lengthening one diameter symmetrically, so in the pendent cut the variation consists in lengthening one end of a diameter of the type cutting. Pendent cut stones are very rarely, if ever used for ring settings, and although a considerable proportion of the stones cut in this make are diamonds, it is very generally employed for all of the light-colored stones through a very wide range of weight.

Intimately related to the pendent-shaped brilliant is the heart-shaped brilliant, illustrated in Fig. 18. This variation of the type bril-

liant cut might be considered as a pendent-shaped brilliant, with the round end somewhat flattened and with the girdle outline broadened until its length about equaled its breadth. In the present example, which was studied from a model of the No. V Cullinan diamond, the crown is shallow and the table relatively large.

No attempt has been made to work out the difficult problem of the optics of the three foregoing variations of the brilliant. There are so many elements to be considered where not even the girdle outline is a constant that we are led to suspect that the lapidaries and diamond cutters have no guiding rule, but make the stone to get the best advant-

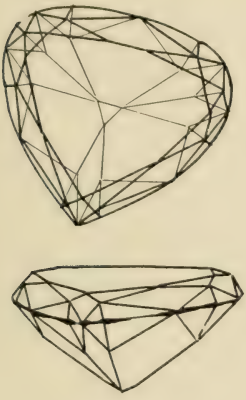


Figure 18

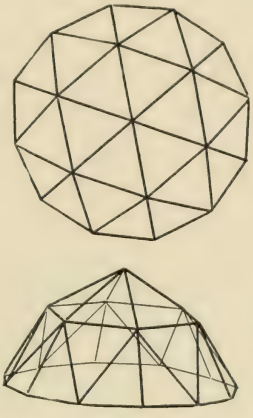


Figure 19

age of weight and spread without considering the angles which give the maximum brilliancy. The three illustrations chosen from the work of so distinguished a lapidary artist as Joseph Asscher, undoubtedly express a very close approximation to ideal proportions for their respective cuttings.

The extremely wide range of forms which are classed by lapidaries are fancy cutting precludes the discussion in a limited space of more than the essentially characteristic variations involving a treatment of the crown facets derived from the brilliant cut. With respect to the pavilion facets these "fancy shapes" have for the most part been given some variation of a step cutting, but even in this there appears to be no set rule and the details of the facetting is largely a matter of individual taste on the part of the lapidaries.

THE ROSE CUT

The "Rose" cut or "Rosette" enjoys a history more ancient, if not more honorable, than the brilliant cut. As far back as the early decades to the 16th century this form of cutting was in vogue for diamonds. It is said that several of the diamonds of the French crown were recut to a rose form by the order of Cardinal Mazarin, an association of names which had led to the tradition that the rose cut was invented by the famous ecclesiastic.

Since the 17th century the rose cut has steadily given place in popularity before the increased luster of each succeeding modification of the brilliant cut, and it is now used only for very small cluster diamonds and for such deep colored stones as Bohemian garnet.

One of the earliest variations of the rose cut is the Holland rose, Fig. 19. In its simplest and probably its oldest form this cutting consisted of only 12 facets above the flat base, arranged in two stepped rows of six each. The rose cut shown in the figure was probably derived from this, the primitive phase, by the addition of 12 facets around the base which correspond to the corner facets of a brilliant cut. The six upper facets constitute the crown and the 18 facets of the lower row are known as the cross facets. As applied to the diamond, much of the light which falls on the facets of the Holland rose in a direction normal to the base is returned to the eye above the base, but owing to the small number of reflections for each pencil of rays the rainbow-like colors which constitute the chief charm of a brilliant cut are lacking.

The Brabant rose, presents the same general arrangement of facets as the Holland rose, but differs from the latter in that the ring of cross facets is steeper and the crown lower. Optically this cutting is not nearly so efficient as the other forms of rose cut, most of the incident rays of light escaping through the base, a fact which probably accounts for its early lapse from popularity. This cutting apparently originated in Antwerp when that city was contending with Amsterdam as a diamond-cutting center and represents an unsuccessful attempt to rival a characteristic Dutch cutting.

Both of the above rose cuts have been slightly varied; as, for instance in the substitution of one instead of two facets in the double cut which takes off the corners of the base, giving to the cut 19 instead of 25 facets. Another variation carries the crown facets of the single cut to the base in a six or eight-sided pyramid, and double cuts each corner, with one facet carried half way up the edge and making the crown facets lozenge shaped. This is known as the cross rose.

The rose recoupee a more elaborate variation of the Holland rose, is shown in Fig. 20. This has twice the number of single cut facets, that is,

24; and because the single cutting is more elaborate, only one double cut facet for each corner is given. This makes a cutting of 37 facets with a 12 sided base. From the point of view of effective brilliancy, the rose recoupee far exceeds the other cuttings of this class, the leakage through the base being relatively small, and in general the light is returned through the crown facets.

The double rose, Fig 21 is a variation hardly less classic than the Holland rose from which it was derived. It has the form of two Holland rose cuttings joined base to base, and is particularly appropriate for stones which are to be used as pendants or pendant eardrops. Set in a loop which clasps the girdle, it would seem that the brilliancy of this

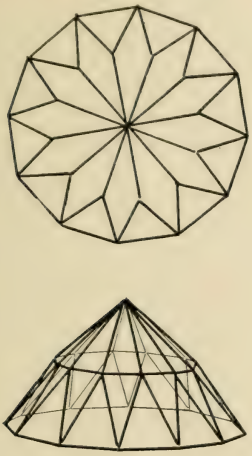


Figure 20

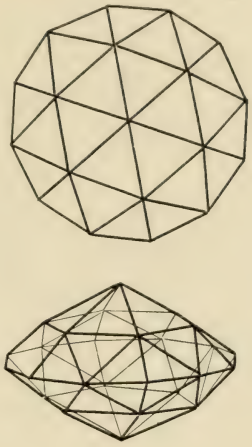


Figure 21

cutting, as applied to diamonds, has been somewhat overlooked; a study of the optics brings out the fact that it gives very effective reflections through the cross facets and that these reflected rays would, in all probability produce through their interference a desirable play of color.

So closely allied to the double rose as to almost constitute part of the same variation are the numerous forms of pendeloque cutting.[1] These may be considered as double rose cuts of which the axis of one end has been drawn out to a very steep crown, while the other end is terminated by a rose of ordinary height of crown or by one with this height slightly depressed. The pendeloque shown in Fig. 22 may be said to be formed by

[1]There appears to be a diversity of nomenclature in relation to this form of cutting, several authors mentioning it as a "briolette" or "briolette brilliant." In using the term "pendeloque" the present author follows the precedent of Dr. Max Bauer.

two cross roses and represents a rather simple cutting in this style. For pendants of the semiprecious stones pendeloque cuttings are eminently adapted and they are met with most frequently in the make of the quartz gems, rock crystal, amethyst, citrine and smoky quartz. The larger stones are given a more elaborate treatment, as in Fig. 23, which was studied from a smoky quartz pendant. Still more elaborate variations are common in the treatment of this cutting, some of them running as high as 88 or more facets. Much latitude is also permissible with regard to the proportion of length to diameter, and the shorter forms when

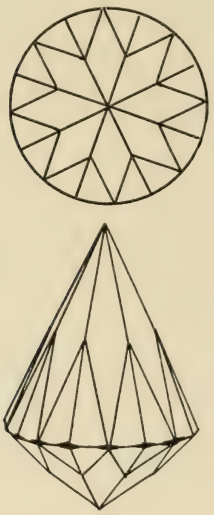


Figure 22

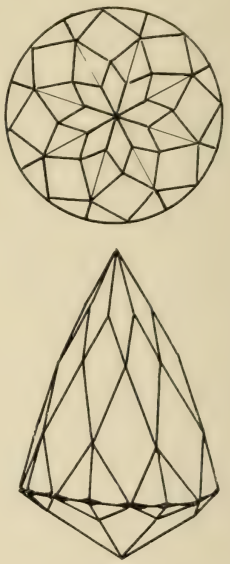


Figure 23

cut from relatively soft stones are usually bored through the axis to admit of their being strung.

From the pendeloque cutting it is but a short step to the beads and other cuttings intended to be strung. One of the most usual forms of round bead cut is the one shown in Fig. 24 which was studied from an amethyst bead of 13¼ carats. This treatment of a facetted bead may be found in almost all the materials used for this purpose, particularly in amethyst and amber. That it is a very ancient and obvious method of facetting is evidenced by the beads of the Gallo-Roman Period shown in Case XXIX of the Gem Series.

A much more unusual bead cutting is that shown in Fig. 25 and which might be termed a stepped bead. It was studied from one of a string of 29 superbly cut rock crystals and represents one from about the

middle of the string which weighed about 15 carats. Some of the larger of these beads were cut with cross facets for the two terminating rows of facets, and, in at least one instance, one end of the axis was treated as in the figure, and the other facetted for two rows as in Fig. 24.

Allied to these bead cuttings is the egg-shaped cutting given to the large blue topaz, illustrated in the frontispiece and to be found in Case VI of the Gem Series. This stone, which represents one of the finest examples of the lapidary's art, is cut with 444 facets of perfect regularity, and is so proportioned that it gives very effective brilliancy.

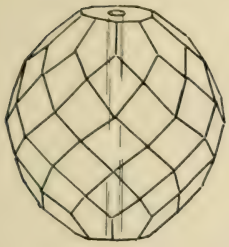


Figure 24

Figure 25

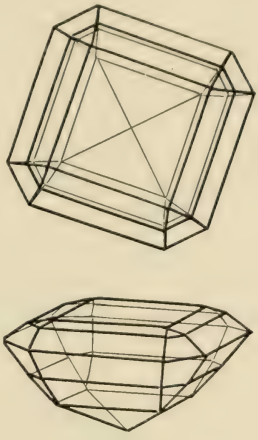


Figure 26

THE STEP CUT

When we turn back to the beginning of the art of shaping gem minerals into forms adapted to jewelry settings, we find a perfectly obvious sequence in the development of these forms. It is a sequence which, in fact, adheres closely to the lines upon which a lapidary of the present day is trained in his art. First, we have the round or oval cabochon cuttings of Celtic, Byzantine and early French jewelry, often somewhat irregular in shape, the simplest and crudest efforts in the dawning art of fashioning stones to enrich the masterpieces of the Medieval gold and silversmiths. With the development of richer design in jewelry there followed a steady progress in gem cutting, and with the call for stones of square and octagonal outline there began to be evolved cuttings with broad table facets flanked by narrow bevels to admit of the stones being gripped by the heavy settings. This early form of facetted cutting, which is essentially a primitive step cut, shows its influence in the presence of a table facet on early forms in the evolution of the brilliant cut. (See Figs. 3 and 4).

From such crude beginnings to the typical emerald cut Fig. 26 of the present day, the advance has been only along the lines of more complex and symmetrical facetting, produced with a view to making a stone of more elegance of outline, where the display of the color is the primary consideration. In this way the form of step cut shown in Fig. 26, is very widely used for emeralds and is given proportions directly dependent on the depth of color in the stone to be cut.

A fairly recent practice in diamond cutting has adapted the step cut to the making of diamond gems of especially choice quality. When applied to diamond, however, the proportions of the step cut must be carefully studied with respect to the effective rays of light which are returned through the crown facets after total reflection within the stone.

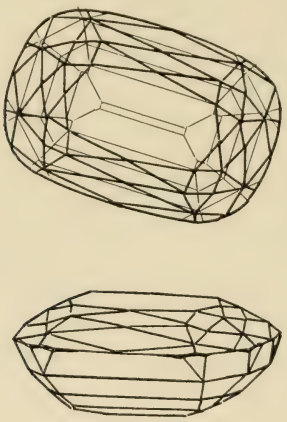


Figure 27

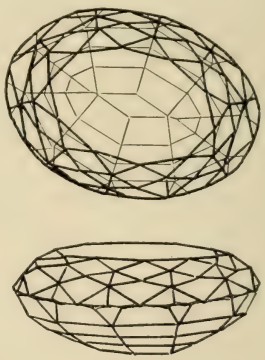


Figure 28

By far the most widely recognized derivatives from the step cut are those combination cuttings which use a brilliant or modified brilliant cut treatment for the crown facets and a stepped facetting for the pavilion end of the stone. One of these derivatives has been already discussed under variations of the brilliant cut, for the reason that it belonged more properly among the cuttings with round girdles than in the present group of cuttings, which include oval and oblong variants of the step cut, notably characterized by their complex multiplication of facets.

Cuttings of this kind are almost universally applied to large stones of the light colored gem minerals, such as amethyst, aquamarine, topaz, citrine, light colored tourmaline, peridot, smoky quartz, etc. In the example illustrated in Fig. 27, which was studied from a blueish green aquamarine of 30½ carats weight, the brilliant cut treatment of the

crown includes two rows of main facets instead of one, the large size of the stone necessitating an increase in the number of facets to give symmetry and surface brilliancy to the cutting.

Fig. 28 was also studied from an aquamarine, in this instance a stone of 13½ carats. The oval shape is produced by the use of 10 instead of eight groups of facets, and, as in the former instance, the main facets are doubled in the crown and the stepped facets of the pavilion are accommodated to the oval girdle by single corner facets. The beauty of this stone has well repaid the lapidary for the labor of cutting 122 facets which constitute its make and it may well be considered a masterpiece of well balanced and accurate gem cutting.

With larger stones the number of facets demanded by this cut may be increased almost indefinately. Leopold Claremont illustrates[1] a very large oval aquamarine which is cut with 313 facets in the crown alone. But unless well proportioned and symmetrically distributed the multiplication of facets in the combination step-brilliant cut tends only to detract the eye from the color, which constitutes the real beauty of the large semi-precious stones.

[1] "The Gem Cutter Craft," page 182.

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SEASONAL RECORDS OF GEOLOGIC TIME

By CHESTER A. REEDS

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Seasonal Records of Geologic Time

BY

CHESTER A. REEDS

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TREE RINGS USED IN MEASURING TIME

Two hundred three years of seasonal records, as shown by the annual rings (natural size) on the section of the big *Sequoia* tree in the American Museum of Natural History. Time represented 1150 A.D. to 1353 A.D.

Seasonal Records of Geologic Time

AS NOTED IN ANNUAL RINGS OF TREES, BANDED GLACIAL CLAYS, AND CERTAIN DEPOSITS MADE DURING PERIODS OF ARID CLIMATE

By CHESTER A. REEDS

Associate Curator of Invertebrate Paleontology, American Museum

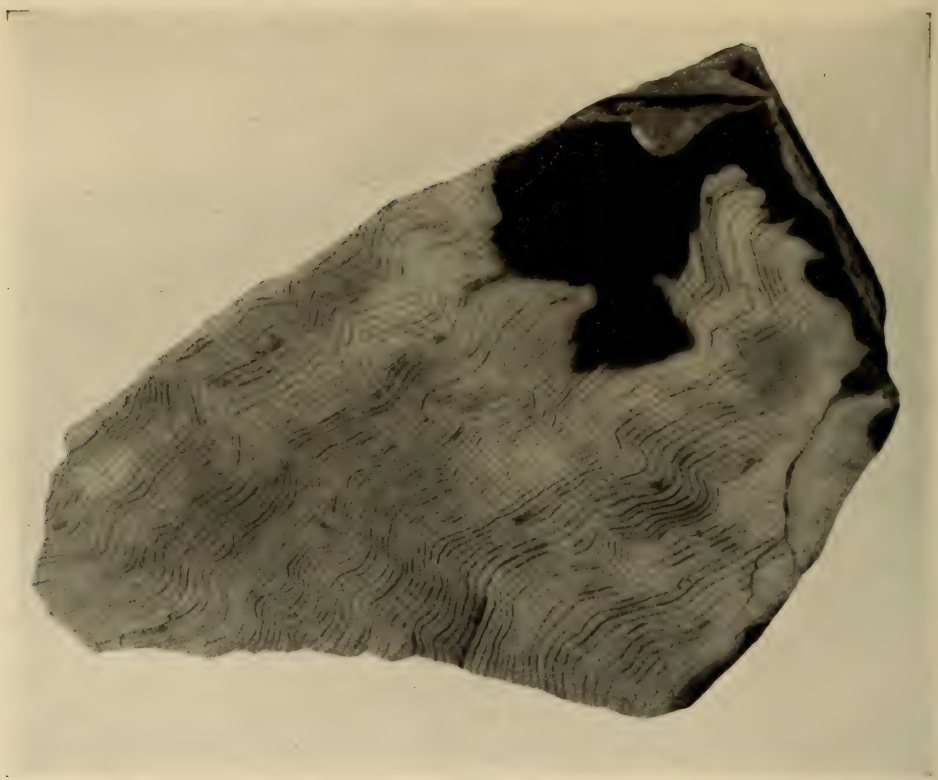
WE are all impressed with the variable daily amount of light and heat received from the sun and with the recurrence of day and night caused by the revolution of the earth on its axis every twenty-four hours. We are not unmindful, too, of the gradual passing of the seasons, spring, summer, autumn, and winter, and the accompanying variations in temperature and moisture, as the earth completes its annual circuit about the sun. The questions naturally arise: what is the net result of these seasonal fluctuations, for how many years have they been going on, and what will be their tendency tomorrow? We turn to the past records for an indication as to the future. We know that there have been seasonal variations for the thousands of years that man has been keeping his calendars and writing history. We also have good reason to assume that they were true for prehistoric man, who kept no tangible records, as well as for the great eons of time that preceded the advent of man upon the earth.

Those of us who have observed nature in one or more of her varied phases are greatly impressed with the effect of the seasonal changes upon the plants, which have adapted their growing periods to spring and summer, and their resting or maturing stages to autumn and winter. The researches of Dr. Ellsworth Huntington and Prof. A. E. Douglass on trees and climate are especially interesting in this connection.

In the trees the seasonal changes are recorded in the annual rings. Soft white cells grow at a rapid rate in the spring. This growth is dependent upon the relative amounts of snowfall and rainfall of the preceding winter as well as upon the porous or compact nature and depth of the soil. In the autumn, due to lowered temperature or diminished water supply, there is a gradual cessation of the activity of the tree. This change is recorded by the deposition of denser and darker material in the cell walls. During the winter, growth practically stops.

Occasionally, due to two stages of growth in one year, superfluous rings may arise, or, due to the lack of a spring development, two or more autumn rings may merge together and an apparent omission of rings will occur. To detect a possible error in counting these abnormal rings, groups of rings in different trees are compared and "cross-identifications" are thus established. Years deficient in rainfall or lowered temperature are more noticeable and more widespread than favorable years, for a deficient year is characterized by an individual ring that is small compared to those beside it. Large rings are more apt to come in groups and are not so extensive geographically as small rings.

Variations in climate can thus be detected in the growth rings of trees. Successive years are not all alike, for a factor like rainfall may be variable; besides, more than one factor may



A portion of a fossil Sequoia tree of Middle Tertiary (Miocene) age from the Yellowstone National Park, showing annual rings

affect the tree rings, such as rainfall, temperature, and length of growing season. In regions where trees have an abundance of moisture there is often noticed a beautiful rhythm of annual rings which matches with the sun-spot cycle of 11.4 years. Other cycles of 6 years, 22 years, 35 years, and 100 years have been noted. In fact, different centuries may have different combinations of climatic cycles. When they are better known, they may give us a basis for long-range weather forecasting. Some of them have been used by Professor Douglass in determining the relative dates of prehistoric ruins in northern New Mexico.[1]

[1]See the article entitled "Dating Our Prehistoric Ruins," by A. E. Douglass, NATURAL HISTORY, January-February, 1921, pp. 27-30.

The longest record of tree growth is that found in the "big trees" of California, the *Sequoia washingtoniana*. Some of these trees have lived for more than 3000 years. In the Jesup collection of North American woods in the American Museum, there is a cross section of a large *Sequoia* tree which was cut in 1894. According to the count of the annual rings this tree started to grow in A.D. 550. Recently Doctor Huntington has added to this exhibit a climatic curve based on the variable growth in the *Sequoia* and has indicated the rise and decline in response to climatic variations of the great governments of the countries bordering the Mediterranean from 1300 B.C. to the present. This comparison is

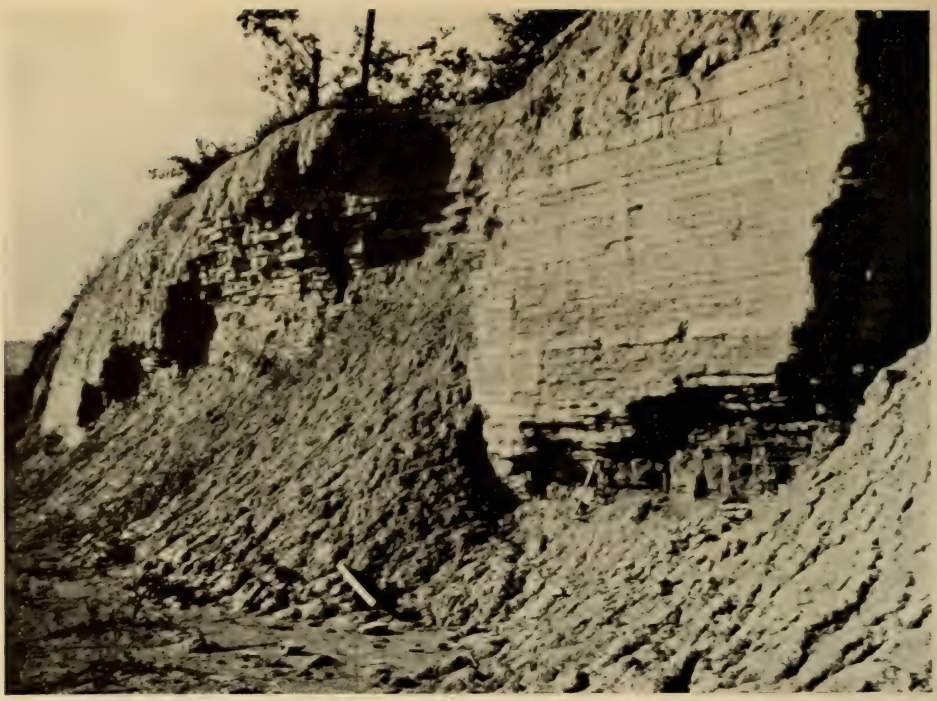
possible since a study of the countries bordering the Mediterranean shows that the climatic pulsations felt there were similar to those indicated by the "big trees" of California, and indeed the climate of the two regions is still of the same type.

From the trunks of fossil trees it is probable that a very much longer record will be obtained. Trunks of fossil *Sequoia* trees occur in the Yellowstone National Park, in the eastern foothills of the Rocky Mountains, and elsewhere, in places where the trees do not now grow. The cross section of the silicified wood sample, p. 372, shows ninety-two well marked rings with a thickness of about one millimeter each. Fossil woods exhibiting annual rings have been found in rocks of various ages from the Upper Devonian Period to the present, that is, as far back as 18,000,000 years ago, but only comparatively few have been collected and are accessible.

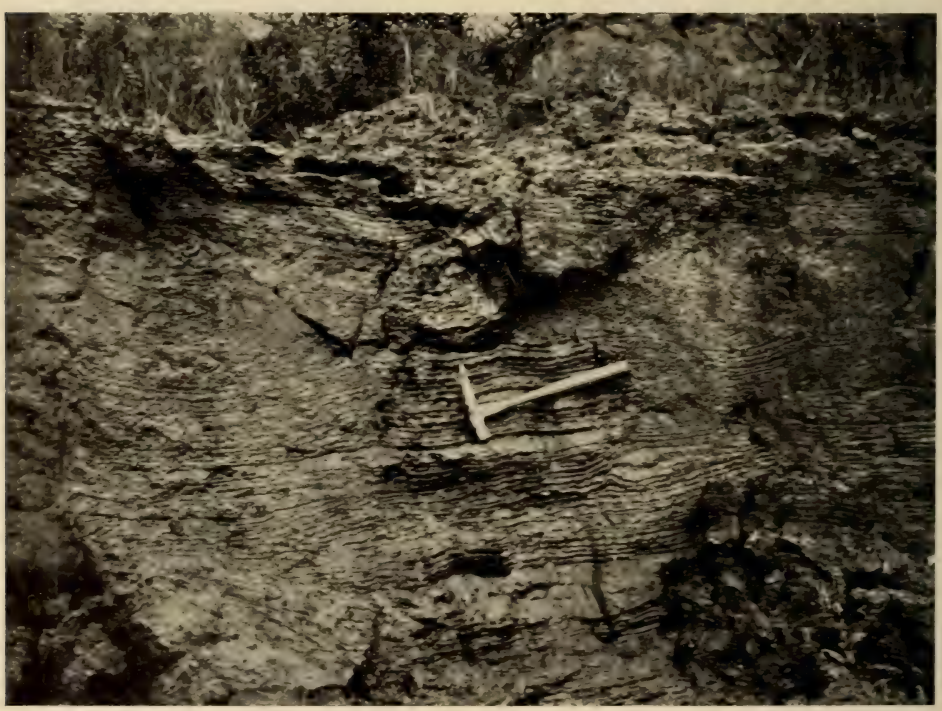
A longer annual record than that afforded by the living *Sequoia* trees has been obtained in Sweden from the glacial clays deposited in fresh-water lakes which laved the retreating ice front of the last continental glacier. The stratified clays of the Hudson, Hackensack, and Connecticut river valleys and of many other points in America were likewise deposited in fresh-water lakes which followed the retreating ice border of the last great North American ice field.

On close inspection these glacial clay deposits show distinct seasonal layers or bands: a summer layer, which is the thicker, of more sandy material, and of lighter color, usually gray; a winter layer, which is the thinner, of very fine clay, and of darker or reddish color, depending upon the color of the rock from which the fine clay particles were derived. In passing upward from a dark winter layer to the

Banded glacial clay (varve clay) from New Haven, Connecticut, showing seven dark winter layers and six lighter summer layers (natural size). An annual deposit consisting of a summer layer and the succeeding winter layer is called a varve. Collected by Dr. E. Antevs, 1922



Postglacial banded clay exposure at Dunnings Point on the Hudson River near Beacon, New York. Photograph by the author, September, 1922



Varve clay from clay pit one-quarter mile north of Mountain View, New Jersey. The deposit was made on the bottom of the former glacial lake, Passaic. Photograph by the author, September, 1922

coarse gray summer layer, the change is abrupt; from the summer layer to the winter layer, however, the change is gradual in all cases. The coarse summer layers have very fine wavy lines of bedding while the fine winter layers are homogenous and uniform in appearance. These seasonal layers alternate in position without exception throughout the deposits. A pair of such layers is called a varve, or annual deposit.

In different years different quantities of sediments were carried to the glacial lakes and consequently there arose variations in the thickness of the varves. Over the several areas of sedimentation, however, the varve for a particular year is approximately of the same relative thickness. Another circumstance of considerable note is that the varves overlap each other very much like the shingles on a roof. This was brought about by the amount of summer melting and the annual retreat of the ice northward. The location of the northern limit of each varve, that is where it touches the bed rock, thus enables one to determine the position of the ice for a particular year as well as the rate of retreat.

In Sweden the rate of glacial retreat was irregular; in Scania and Belecking about 75 meters a year. Before reaching the two great Fennoscandian moraines near Stockholm, which represent distinctly adverse climatic conditions, it increased to 100 meters or a little more. North of the great moraines the retreat fluctuated from 100 to 300 meters or more a year and only occasionally was it interrupted by a stoppage or small advance.

This retreat of the last glaciation in Sweden, (see map) may be subdivided and summarized as follows:

(1) Daniglacial—Part of Denmark, part of Scania, and north central Germany south of the Baltic Moraine. Time undetermined.

(2) Gotiglacial—Retreat from the terminal moraines in middle Scania to the southern border of the great Fennoscandian moraines south of Stockholm, 11,600 B.C. to 8600 B.C., or 3000 years.

Retreat stages of the last glaciation in northwestern Europe. After Osborn and Reeds, 1922

(3) Finiglacial—The retreat from the southernmost of the Fennoscandian moraines to the parting of the land ice into two parts in the Ragunda district, 8600 B.C. to 6600 B.C., or 2000 years.

(4) Postglacial of Swedish geologists, based on the work of Lidén in the valley of the river Angermanälven, 6600 B.C. to 1900 A.D., or 8500 years. The above figures give a total of 13,500 years for the retreat of the last ice sheet from central Scania to the present small ice caps in north central Sweden.

The glacial clay studies in Sweden have been made chiefly by Baron Gerard de Geer[1] and a number of younger men trained by him, particularly Dr. R. Lidén and Dr. E. Antevs. It was in 1878 that De Geer arrived at the conclusion that a pair of these seasonal layers constituted an annual deposit, or varve. De Geer also developed a method of correlating these

[1]See the article entitled "Baron Gerard de Geer and His Work" by James F. Kemp. Natural History, Vol. XXI, pp. 31-3.

deposits not only in the same region but also in different regions.

Studies of glacial clay, deposited during the retreat of the last ice sheet in North America, have been made by a few investigators, particularly Antevs, 1921–22, who has determined a sequence of varve clays representing 4100 years for the retreat of the ice front from Hartford, Connecticut, to Saint Johnsbury, Vermont, a distance of 185 miles. The average rate of retreat was a little more than one mile in 22 years, but it was not regular. Between Springfield and Amherst, Massachusetts, a distance of twenty miles, it was much slower, about a mile in 47.5 years. Then for 350 years the ice front remained in the vicinity of Amherst, but at the termination of that span of years retreated more rapidly, about a mile in 15 to 16 years. The results of Doctor Antevs' investigations have been published in book form, under the title of *The Recession of the Last Ice Sheet in New England*, by the American Geographical Society, New York, 1922.

Banded clays of an earlier glaciation were described by Prof. R. W. Sayles in 1916 from the Sqantum peninsula near Boston, Massachusetts. It is estimated that they are 13,000,000 years older than the clays deposited during the retreat of the last or Quaternary (Pleistocene) glaciation of northwestern Europe and eastern North America. They are 800 feet thick and have been referred to the Permian Age, a period nearly one-fourth the way down the geological scale (see p. 378). Since deposition these ancient banded clays have been converted by diastrophic movements into slate or argillite, but they still retain their original relations and characteristics.

The most ancient glacial clays with varves so far noted appear near the base of the geological column and are estimated to be 37,000,000 years old or older. They exist as argillites associated with the Huronian glacial drift deposits at Cobalt, Ontario, Canada. According to the late Prof. Joseph Barrell, they occur at the south end of Cobalt Lake; they are delicately banded and indicate rhythmic deposition. The bands are grouped in series that show larger rhythms representing climatic fluctuations covering periods of years.

Deposits made under arid climates sometimes show seasonal developments. According to R. Görgey (1911) seasonal bands appear in certain salt deposits of northern Germany. Varves representing 5653 years have been noted in these deposits. The salt beds which exhibit this banding are associated with red formations and gypsum of Upper Permian age. Unlike the varve clays, which formed under a moist glacial climate, these salt deposits were developed from brines under a period of continued arid climate characterized by excessive evaporation during the summer.

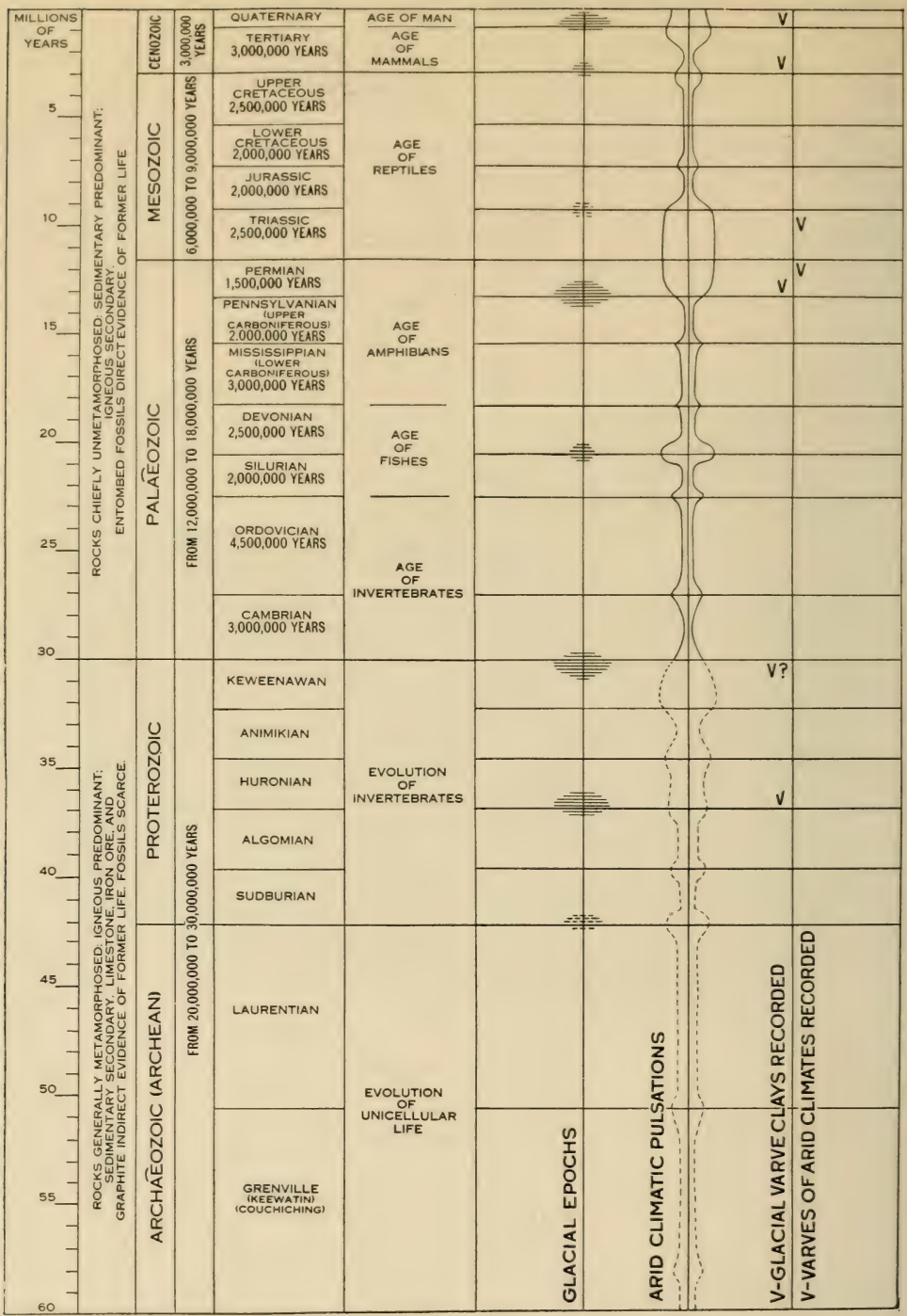
Another example of seasonal bands formed under an arid climate is furnished by the specimen of Triassic red sandstone shown on p. 377, which the author found in September, 1922, as a sporadic bowlder in the five feet of "yellow drift" overlying the late glacial clays of the Quaternary (Pleistocene) Period in the vicinity of Little Ferry, New Jersey. The normal position of the Triassic rocks in this region is beneath and on the margins of the Pleistocene clays. In cross section this specimen shows more than nineteen annual bands of red sand. The summer layers are the lighter in color and are

relatively thick with moderately coarse sand; the winter layers are the darker and are thin, being composed of a finer grained sand than the summer bands. The varves are quite regular and show marked seasonal differences.

From the instances cited it is apparent that seasonal records of one kind or another occur at widely separated intervals in geologic time, in fact so early and so late and with sufficient frequency to justify one in assuming that seasonal changes took place regularly from year to year throughout all geologic history. Seasonal records, however, have not been preserved for every year, as a certain combination of circumstances must exist to bring about deposition. Sharply marked seasonal deposits were formed either under glacial or under arid conditions, that is, the two extremes of climate. Furthermore, their presence is restricted to the fresh-water lakes which laved the retreating ice front or to the vanishing lakes of arid regions. The marine formations, which constitute the greater portion of the stratified rocks of the earth's crust, show no varves or seasonal banding; hence deposits exhibiting varves form only a small part of the geologic record. Such deposits are of the greatest importance, however, in the study of geochronology, climates past and present, and the evolution of life.

Cross section of varves in a Triassic red sandstone bowlder from Little Ferry, New Jersey

Where varves exist, they can be counted and the actual length of time involved in their deposition ascertained. In the many instances, however, where they do not exist, the duration of time is uncertain; nevertheless, the thou-



A CHART OF GEOLOGIC TIME

The glacial epochs are shown by the shaded areas (dotted where the data are indirect); the arid climatic pulsations by a curved line (dotted where the data are indefinite); and the varve deposits by a V, placed on the left of the ruled line where glacial action is responsible and on the right of the line where the varves were produced by arid climates

sands of sedimentary beds represent millions of years for their deposition. Competent observers using different criteria have made various estimates as to the age of the earth. Some say that it may be 60, 100, 200, or even 750 million years old. Whatever the true estimate may be, there are actual beds of rock which represent a tremendous length of time for their deposition.

In recent years many geologists have concluded that the earth's climate has pulsated back and forth and that a stable climate has not prevailed for any great length of geologic time. There have been periods when extensive land areas, now comparatively free of ice, were covered with great ice sheets. At other times arid to semi-arid or desert conditions oftentimes prevailed in the same or even higher latitudes. To account for changes in civilization at various places in historic times, Prof. A. Penck and Dr. E. Huntington point to the shifting of climatic zones back and forth and cite examples along the northern and southern margins of the Sahara and Sonoran deserts.

Now it may be observed that due to repeated oscillations of the climate during geologic time from one extreme to the other, life has passed through successive crises and that each crisis was a step forward toward the estate of man. The various groups of life which have been successively dominant on the earth have been listed in the life column on p. 000. That these various classes of life are genetically connected is known (1) from the recapitulation, in the embryological stages of the higher animals, of the types of life that have preceded them; (2) from the finding in the geological record of large numbers of fossil specimens which bear witness of this connection and development.

Variations in climate should not be regarded as the sole cause of evolution but one of four or more contributing factors which Prof. Henry Fairfield Osborn has considered in his book, *The Origin and Evolution of Life.* It may be noted, however, that geologic and secular changes of environment have preceded many of the most profound changes in life.

In the Archæozoic Era, which embraces the oldest rocks, there is indirect evidence that unicellular forms of life were present, also that nothing higher existed.

The Lower Huronian Period, with an extensive glaciation in southern Canada and other parts of the world, was among the first of the critical life periods. The Archæocyathinæ, coral-like animals, appear in great numbers before the close of the period. They represent the oldest invertebrates known and an early step forward in the evolution of life from the unicellular forms.

Toward the close of the Proterozoic Era another pronounced glacial climate prevailed in various parts of the world, the net result of which was the sudden appearance in the Cambrian rocks of numerous examples of all classes of marine invertebrates. It is also probable that the tendency toward vertebrate life was initiated at this time, for primitive fossil fishes have been found in the Upper Ordovician rocks of Colorado and Wyoming.

The next important crisis occurred in the late Devonian when, due to the rather extensive arid conditions in many parts of the world, there was an emergence of the earliest vertebrates from the water. Huntington says it was drought which apparently drove our

fishlike ancestors out of the water upon the land. He considers this a most momentous step, for only in the highly varied environment of the land does brain power develop rapidly.

Glacial conditions which were to have a far-reaching effect upon life returned in the late Pennsylvanian and again in the Permian periods. The Permian glaciation was prominent in both the southern and northern hemispheres to within 30° of the equator. It was during these trying times that the warm-blooded mammals probably arose. Their bones, however, have not been found earlier than the Upper Triassic. According to Huntington, the transition from cold-blooded to warm-blooded animals represents one of the most profound developments in the history of evolution.

Throughout the Mesozoic Era the reptiles were the grand masters of the realms of land, air, and sea. During this time they waxed strong, deployed widely, and became adjusted to their environment. Then there came a great change over the landscape in the early Tertiary: the Rocky Mountains were uplifted, seas and marshy lowlands were drained, glaciation returned, the reptile horde was diminished, and the mammals became the dominant class.

The mammals in turn took on many diverse forms and, like the reptiles, occupied all the media of land, water, and air during the millions of years of the Tertiary Period. When they had reached a condition of complete dominance and adaptation, they too were suddenly wiped out in wholesale lots. This may be attributed directly or indirectly to the severe climatic vicissitudes of the Pleistocene or early Quaternary glaciations.

The Quaternary Period is called the Age of Man. In Europe south of the fifty-third parallel evidences of Pleistocene man and even of a late Tertiary (Pliocene) man have been found. Successive types of men lived, struggled, and endured the privations of the glacial and interglacial epochs. During these times the cultural development of man centered about the perfection of stone implements of chipped flint, the palæolithic stage; then during the short Postglacial stage, with its minor climatic oscillations, he passed rapidly through the neolithic into the historic and modern culture stages. According to Huntington, it was apparently this Glacial Period which chiefly stimulated man's mental development and caused his intelligence to dominate the earth.

We pause on the threshold of the future; we dare not enter, for we have a profound respect for the past. We know that this is the Age of Man but we do not know what the next age will be. We feel assured that seasonal and climatic variations will continue in a pulsatory way as before, but as to man he will in all probability succumb in time, as did his ancestors, to the natural forces that caused him to rise and conquer.

FOR THE PEOPLE

FOR EDUCATION

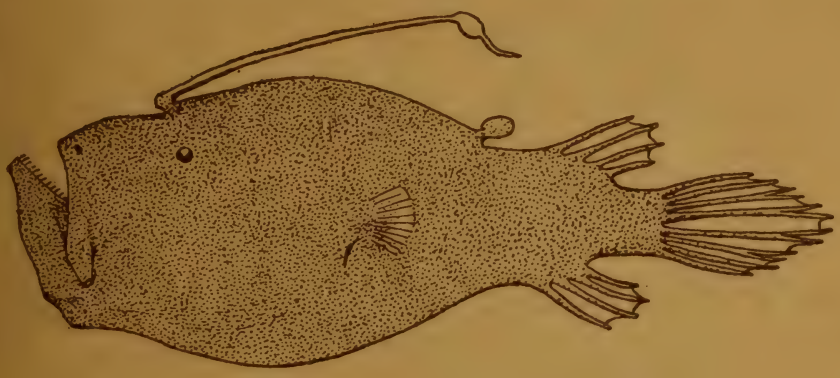
FOR SCIENCE

THE AMERICAN MUSEUM OF NATURAL HISTORY

DEEP SEA FISHES

BY

LOUIS HUSSAKOF



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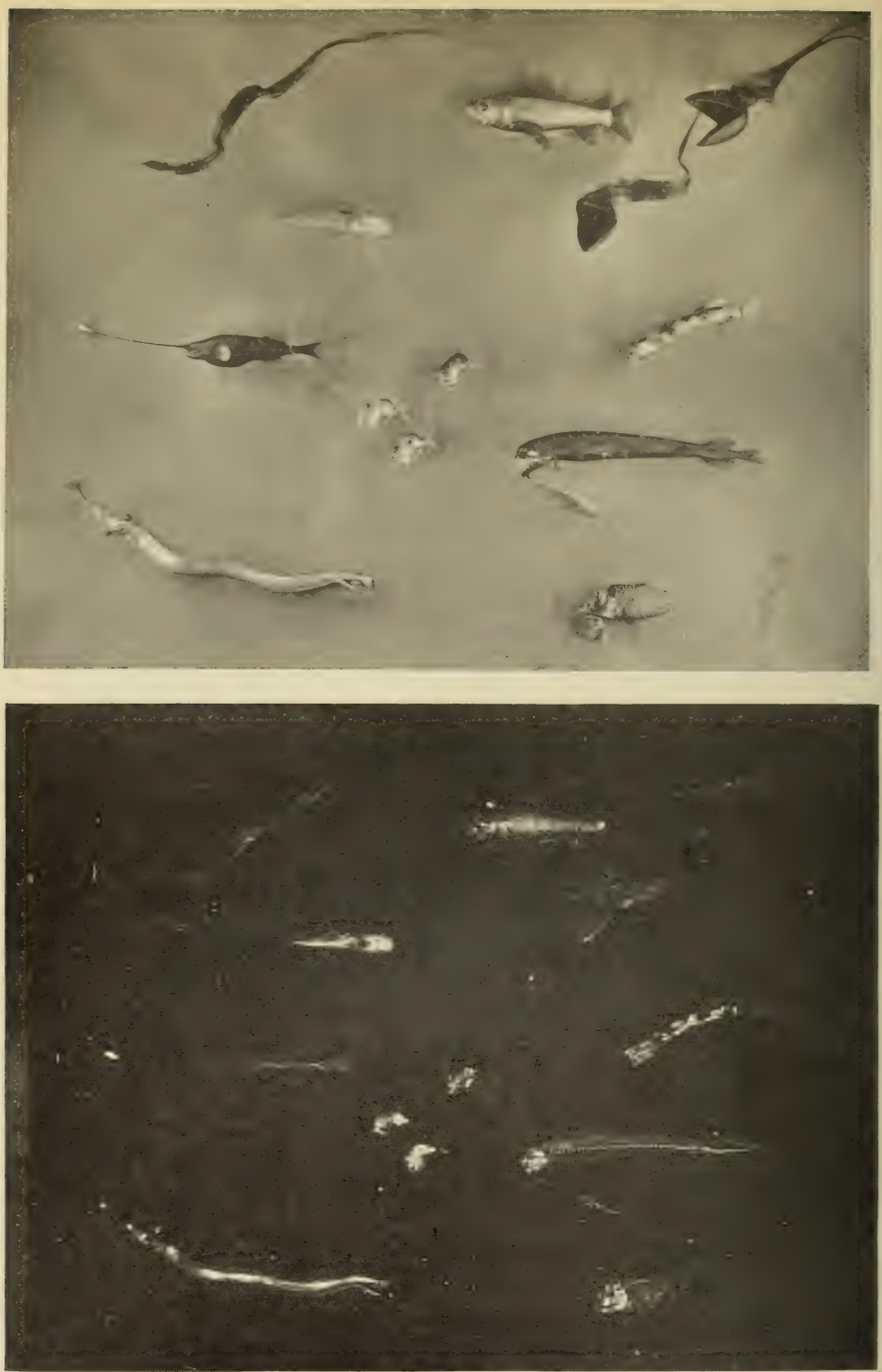
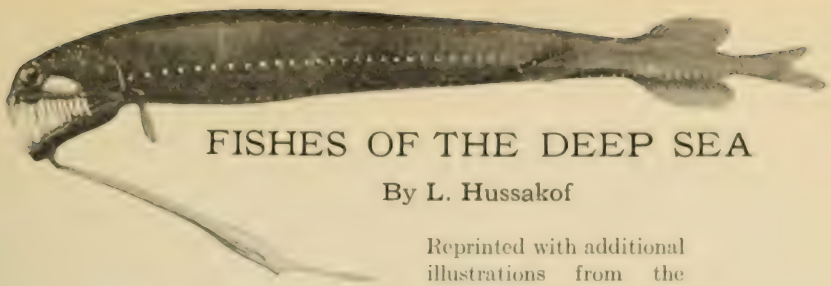


SOME DEEP-SEA FISHES

Some characteristic types of fishes found in the profound depths of the sea, half a mile or more from the surface, photographed from a group installed in the hall of fishes in the American Museum. The illumination of the group is so adjusted that the fishes are seen first for a few seconds in full light, and then in darkness as they are supposed to appear in the sea, lit up only by their own phosphorescent organs

The specimens are models, mostly enlarged several times the natural size. The fishes were prepared by Mr. F F. Horter of the Museum's department of taxidermy, under the direction of Dr. L. Hussakof



FISHES OF THE DEEP SEA

By L. Hussakof

Reprinted with additional illustrations from the American Museum Journal for 1915, Vol. XV, pages 248–253.

UP to the time of the "Challenger" expedition, very little was known regarding the fish life of the abyssal depths of the sea. Only about thirty species were known. But the wonderful collections brought back by the "Challenger" from her four-year cruise (1873–1876) made known the vast diversity, the strangeness and even weirdness of this fish fauna. Several hundred kinds of deep-sea fishes had been collected—some of them dredged from a depth of more than a mile—and it required a huge quarto[1] to describe and picture them. From this volume dates our real knowledge of the fishes of the abyssal deep. The "Challenger" expedition was, indeed, a "Columbus voyage" in ichthyology; it opened a new chapter in the history of the science.

Since that time many deep-sea exploring expeditions have been sent out by the various nations, and hosts of other fishes have been brought up from the oceans in all parts of the world. More than a thousand species are now known, and we can appreciate at its full value the richness and strangeness of this fauna. A large proportion of these fishes are described and figured in two quarto volumes by G. Brown Goode and Tarleton H. Bean, entitled *Oceanic Ichthyology*, published by the U. S. National Museum. Moreover, not only do we know the fishes themselves, but as a result of the scientific investigations carried on by the various expeditions, we now know a good deal of the physical conditions under which they live, so that we can, in a measure at least, explain the why and wherefore of their extraordinary characteristics.

When we think of life in the deep sea, there comes to mind, first of all, the enormous pressure which these creatures must withstand. This pressure becomes the greater the deeper we go down, and in the profoundest depths it equals thousands of pounds to the square inch. The result of this pressure is that the tissues of these fishes are tender and loosely knitted together. When they are brought up out of the dark depths, and the great pressure under which they live is removed, the explosion of the gases within them bulges out the eyes, and often blows out the viscera through the mouth, while the muscles collapse, leaving them soft and flabby like moist rags. Most deep-sea fishes are very small also, usually only a few inches in length, and it is probable that this reduction in size has come about to some extent at least, from the great pressure under which they live.

Another important condition is the dimness of light, or even darkness in the profound depths of the sea. If we imagine ourselves descending into the deep ocean, we see the light grow dimmer and dimmer as we go down, until

[1] *Challenger Reports*, Vol. XXII, 1887.

finally a level is reached beyond which no light penetrates at all. The entire avst depth below it is in eternal darkness. Now the fishes living in this dim light, or in total darkness, have been profoundly modified by it. In some forms the eyes have become very small, and in some cases have entirely disappeared. There are even fishes in which the skin and scales of the body have grown over the place where the eyes should be, so that these fishes are, as has been aptly said, "blind beyond redemption." Other forms, on the other hand, have been affected in an entirely different way. The eyes, instead of growing smaller, have grown larger, as if in an attempt to catch every fleeting ray of light. In some fishes this has been carried so far that the eyes have become like enormous goggles.

Most deep-sea fishes have luminous organs of one kind or another, so that they carry their own light about with them. In some the entire body glimmers, the coating of slime which exudes from the pores and lateral canals emitting a soft silvery glow. In others, rows of minute, luminous organs run along the sides of the body, or there are flashing light-spots on the head or face. What a wonderful sight would be to us a small black fish flitting through the silence and darkness of the deep with its headlights and row of pores gleaming through the darkness like some small ship passing through the night with its portholes all aglow! Some deep-sea fishes have a luminous organ at the end of a feeler on the head. This is waved to and fro to act as a lure to attract the prey.

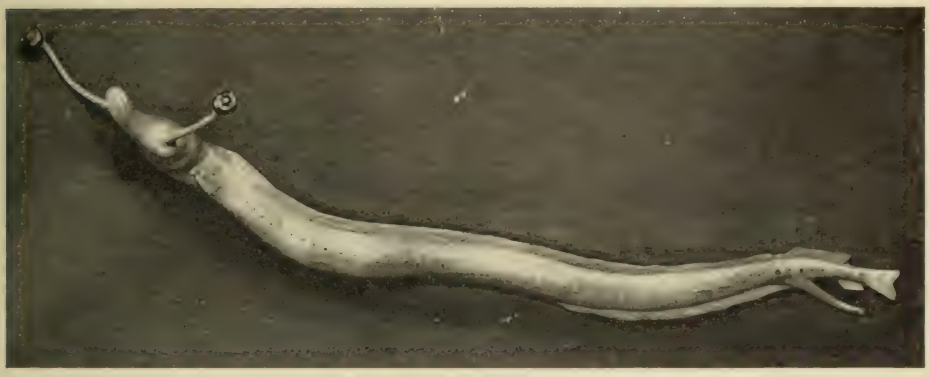
In this deep-sea fish the head glows with a soft pale light, while the body is quite dark, being covered with large opaque scales. The species (*?Opisthoproctus soleatus*) is known by only two examples dredged from a depth of two and a half miles; one off the northern, and the other off the western coast of Africa

This specimen is not shown in the general photograph of the group, having been cut out for convenience in reproduction. It is situated in the group below the bottom fish on the right-hand side

A pertinent question may be asked: How do we know these fishes glow and glimmer, since no human eye has ever beheld them in their abyssal home? We know this partly from analogy and partly from actual observation. When one is in a boat in the tropics, on one of those sultry nights when everything is a dead calm, and the black clouds hang

so low that sky and sea form one continuous blackness, then one may see the glimmering fishes darting out of the path of the boat, their forms, silvery and ghostlike, outlined for one moment against the blackness of the sea. This effect is chiefly due to the oxidizing of the slimy secretion covering their bodies. Why shall we not believe, then, that in deep-sea fishes a similar phenomenon takes place, particularly as in many of them, the slime pores and canals are greatly developed and must exude large quantities of slime? Then too, on deep-sea expeditions, on favorable occasions, as for instance, a dark calm night, fishes that have been brought to the surface and placed in water were seen to flash light from the ends of the tentacles or the phosphorescent pores, precisely as we should have expected from a study of these organs. Major Alcock, in his interesting volume *A Naturalist in Indian Seas*, mentions a specimen brought up from a profound depth which "glimmered like a ghost as it lay dead at the bottom of the pail of turbid sea-water." So that by inference, as well as by actual observation, we must believe that what we call luminous organs in deep-sea fishes, emit light into the darkness about them. In the case of fishes totally blind, the absence of light is compensated for by the development of enormous antennæ-like feelers, modified from fin rays, so that these fishes can feel their way, as it were, through the darkness.

The absence of light however entails another important consequence. As is well known, no plant life can exist in darkness. There is, therefore, no vegetation of any kind in the profound depths of the sea. The deep-sea fishes are, in consequence, all carnivorous, the more powerful ones seizing and devouring the weaker ones. It is a cold black world where might reigns supreme. Many have enormous mouths, and formidable teeth to insure holding the prey. In some forms the teeth are so large that the mouth cannot be shut! Moreover, since meals are perforce far between, they must be as large as possible; hence many forms have extraordinarily capacious stomachs. Speci-

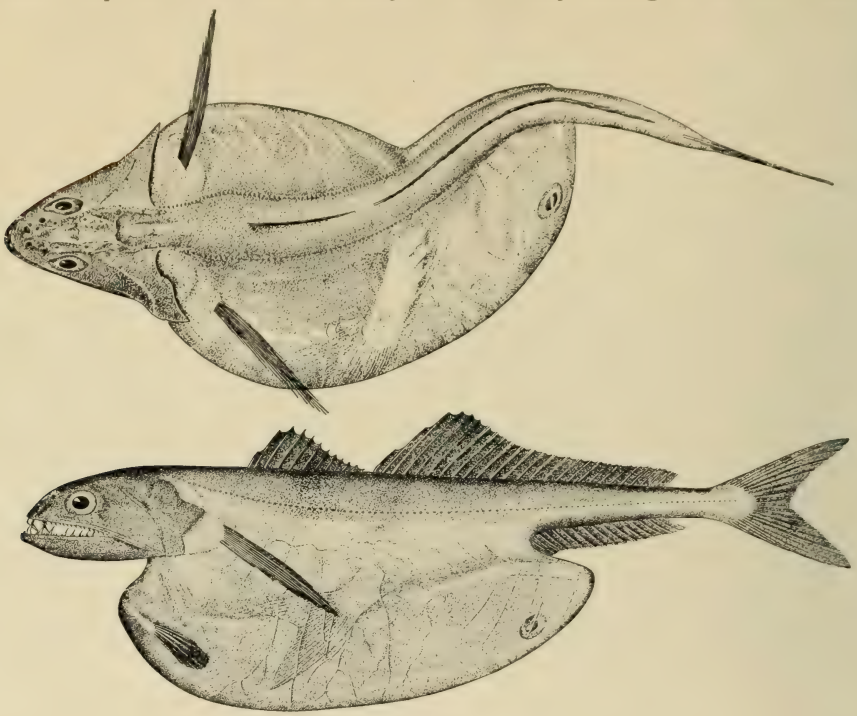


A small, silvery, eel-like fish which has been found in all the oceans at depths ranging from a little less than a mile to two and one-half miles. It has a row of luminous pores running the length of the body; and, in the blackness of the profound depths it must appear like a miniature long dark boat with gleaming portholes. Its greenish, glittering eyes are perched on the ends of slender, hornlike tentacles—a feature which has suggested its scientific name, *Stylophthalmus paradoxus*

mens have been dredged from the deep which were enormously distended through having swallowed fishes larger than themselves.

The temperature of the water in the profound depths of the sea is always low and near the freezing point. This is true everywhere, even at the equator. Undoubtedly this has an effect upon the fishes, although it is not yet known what it is. The amount of oxygen dissolved in the water also, is much less than in water nearer the surface. The breathing apparatus of the deep-sea fishes is modified to suit these peculiar conditions. The gill filaments have become much reduced in size, and in a number of instances some of the gill-arches bear no gill filaments at all. The fishes are apparently adapted to a much smaller oxygen supply than those living in rivers or in the shallow sea.

When we think of the vast diversity among these fishes, the question arises: Are they all representatives of a single family, or group, that has become specially adapted to life in the deep sea; or do they belong to different families or groups? One need hardly be an ichthyologist to answer this question. Even a cursory examination of the plates in a work on deep-sea fishes will show that different types are represented. In fact, a great many families are included in the deep-sea fauna. There are sharks and rays; salmonoids, herrings, perches, eels, and representatives of many other families. We can explain this heterogeneity among them in this way: we may imagine that fishes of many different kinds in their search, so to speak, for the unoccupied corners of the sea, found a haven in these deeper waters where they were



CHIASMODON

A fish that swallows fishes larger than itself; the original of this picture was nine inches long and had caught a fish eleven inches long

free from pursuit by their enemies. In the course of time they migrated farther and farther into the deep, a change in habits taking place *pari passu* with the changes in structure. Having started out with different degrees of variability, they became differentiated in diverse directions, so that while some developed enormous mouths, powerful teeth, or phosphorescent organs, others became bottom-living and partly or completely lost their eyes. Still others developed long feelers for groping their way through the darkness. Now and again, however, fishes of separate groups developed similar structures, so that there are many striking cases among deep-sea fishes of what the biologist calls "convergence," or parallelism.

CHIMAERA A DEEP SEA "SILVER SHARK"

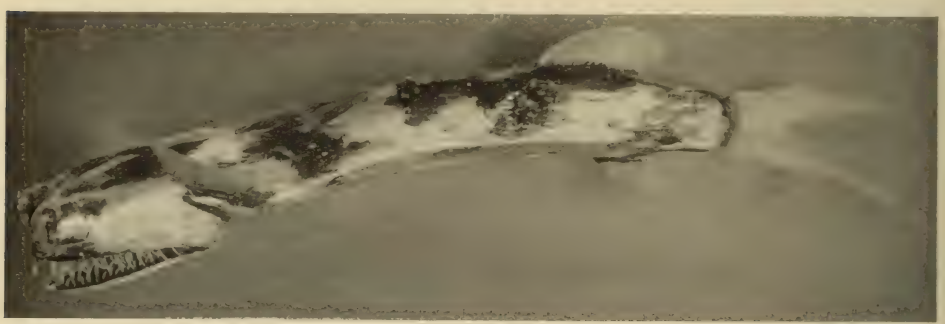
A group comprising ten noteworthy examples of deep-sea fishes forms part of the exhibit of the Department of Fishes and may be found in the north corridor, second floor, by the Paddlefish group. It was prepared by F. F. Horter and is the result of long and patient work and great ingenuity in overcoming difficulties. It is not, of course, a group in the sense of the habitat groups displayed in the Museum; it is not a section, so to speak, taken from nature and transplanted to the Museum. In nature so many deep-sea fishes are not to be found in so small a space. What the group represents is a number of fishes which are in nature scattered over a vast area and through a great height of water, here brought together for museum purposes into a few square feet of space. Each fish is reproduced accurately with its phosphorescent pores and tentacles as these are known to exist. With one or two exceptions they are enlarged several times, as the fishes themselves are very small. And since it is known that the phosphorescent organs do not glow with a steady light, the illumination of the group has been arranged so as to have these luminous organs flash intermittently. Furthermore, the installation is arranged so that one may view the fishes for a few seconds in full light, as if in a synoptic exhibit, and then see them, when the light goes out, as they are supposed to appear in the darkness of the profound depths, lit up only by their own phosphorescent organs.

Near the top of the group is seen a fish which lives on the border line between the region of dimness and total darkness. Many of the fishes living in this region are not of a uniform sombre hue, but are brilliantly colored. *Neoscopelus* is one of these. The body is "one dazzling sheen of purple and silver and burnished gold, amid which is a sparkling constellation of luminous organs" (Alcock).

The glowing fish in the center is *Barathronus diaphanus*, a small fish known from a single specimen, which was dredged in the Indian Ocean at a depth of a little over four-fifths of a mile. The model of it is one and one-half times the natural size. The phosphorescent fish with the curious long tail (at the right) is *Gigantura chuni*. It, also, is known by only a single specimen. This was brought up from a depth of four-fifths of a mile in the Gulf of Guinea, on the west coast of Africa. The model is twice the natural size.

The two dark fishes with enormous gaping mouths (near the top, at the right) are *Gastrostomus bairdi*. This species is commoner than some of the others, a number of specimens being in several museums. The models of it in the group are copied life-size from a specimen in the Museum. The species occurs in the Atlantic Ocean, near the American coast, in the path of ocean liners. Specimens have been dredged from a depth of nearly three miles.

Near the bottom of the group at the left-hand side, is seen an eel-like fish with a line of lit-up pores. This is an enlarged model of *Stylophthalmus paradoxus*, a small silvery fish widely distributed in all the oceans, whose young also are known. The generic name it bears was given it in allusion to the fact that the eyes are perched on long slender tentacles. The species ranges from a depth of a little less than a mile to two and one-half miles. Another form with tentacles is *Gigantactis vanhœffeni*, a species typical of many deep-sea fishes which have a tentacle, terminating in a luminous organ, attached to the head. This tentacle serves as a lure for attracting prey. The present species is known by only two specimens which were found in the Indian Ocean at a mile and a mile and a half from the surface. The creature is a very small fish, the model being enlarged six times.



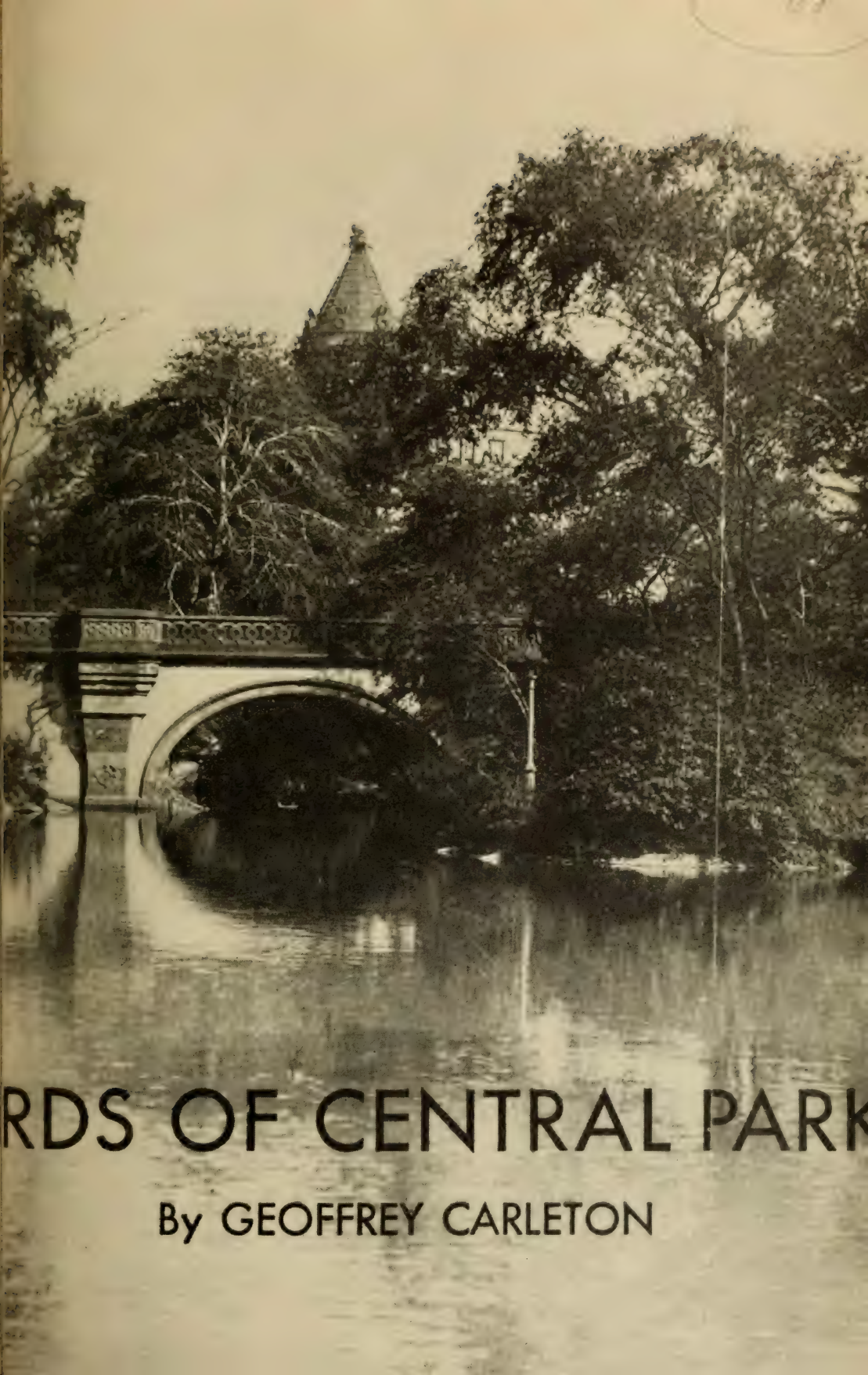
This strange deep-sea fish (*Gigantura chuni*) is known by only a single specimen dredged from a depth of four-fifths of a mile, in the Gulf of Guinea on the west coast of Africa. The body of the fish is a shimmering glow of iridescence, while the protruding eyes shine like automobile headlights. The formidable teeth mark it as a ferocious carnivore

Besides this group, enlarged representations of twenty other species are shown in a case at one end of the systematic series of fishes.

FOR THE PEOPLE

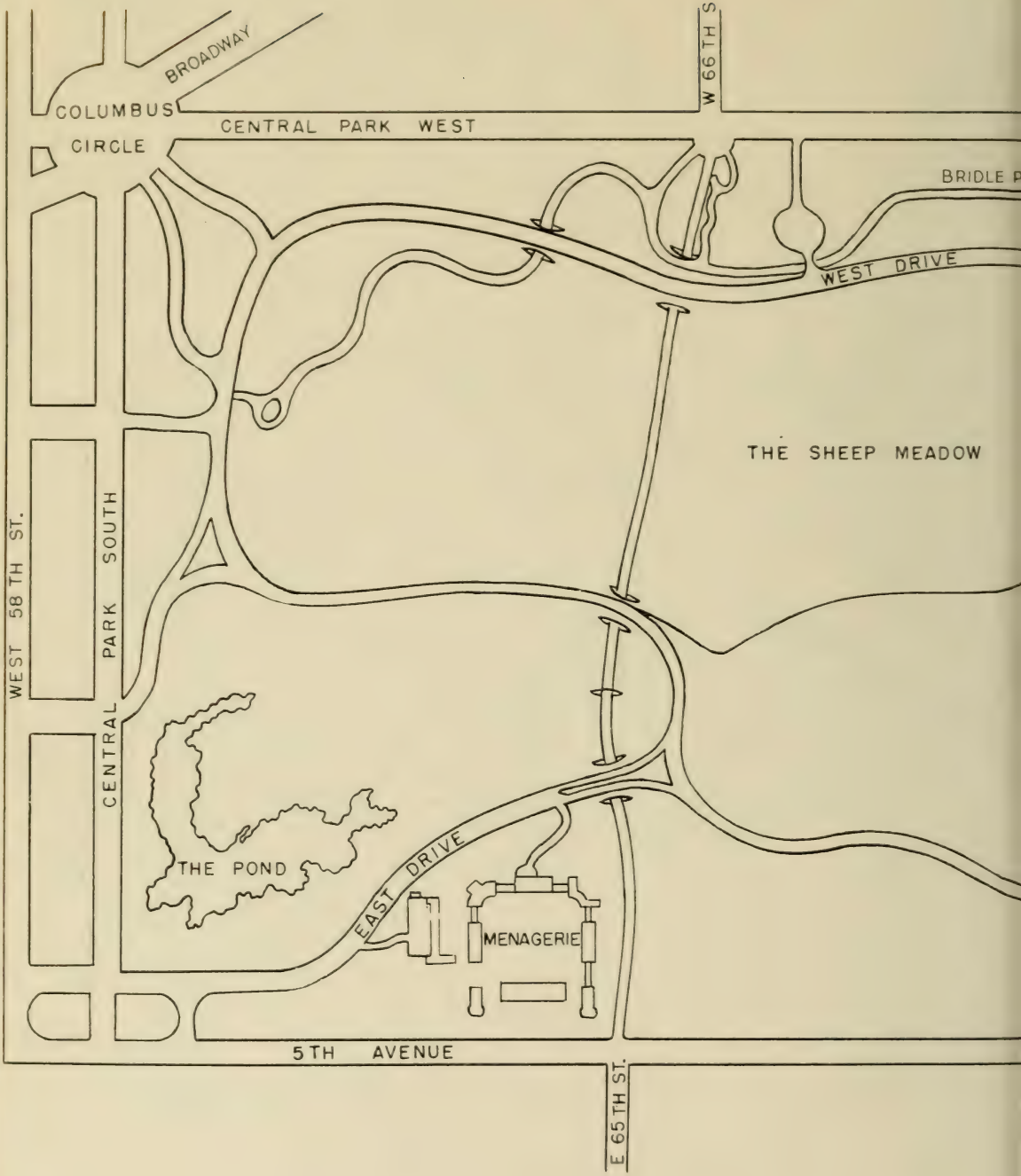
FOR EDUCATION

FOR SCIENCE



RDS OF CENTRAL PARK

By GEOFFREY CARLETON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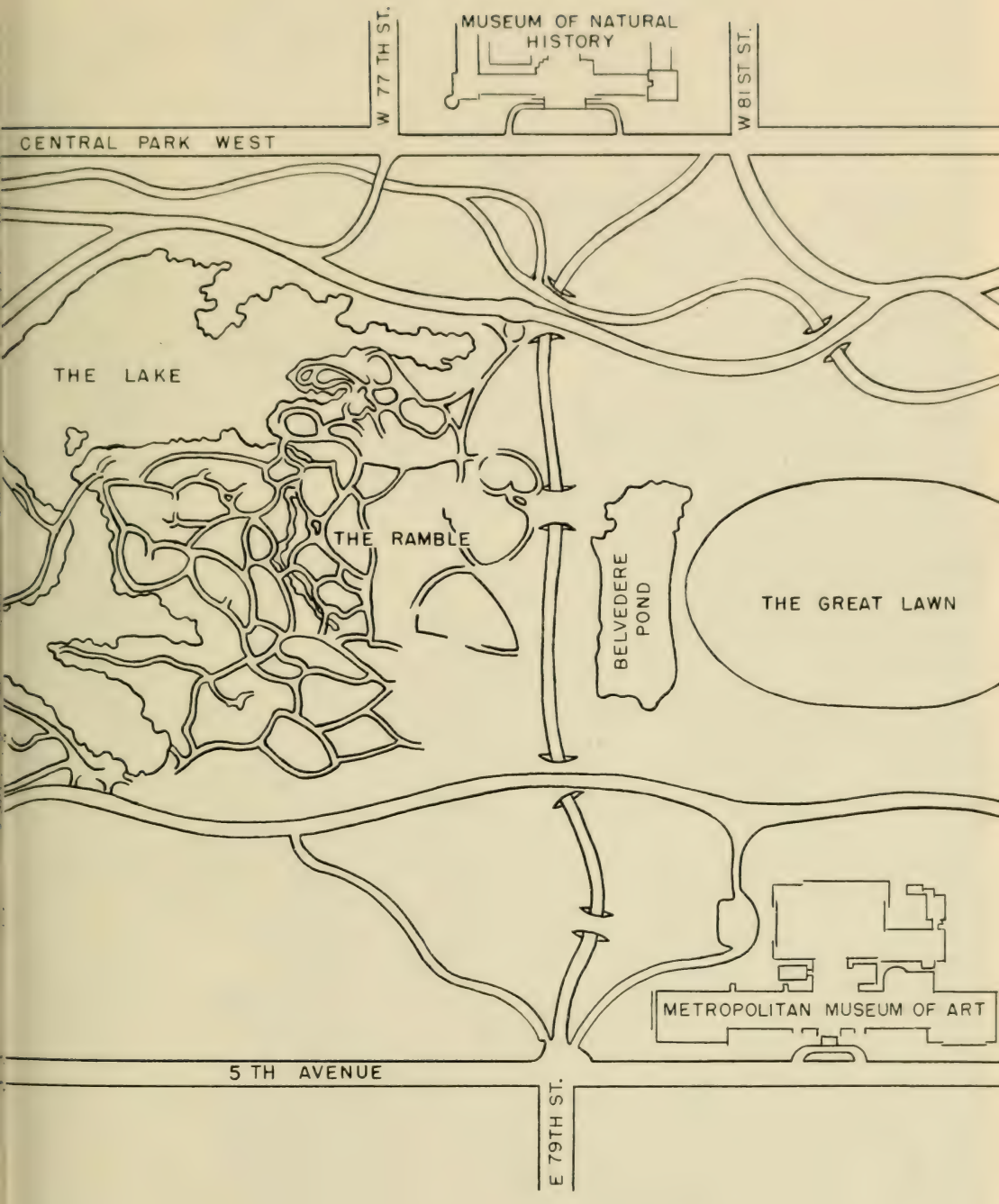
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Photograph by Allan D. Cruickshank

CHESTNUT-SIDED WARBLER

BIRDS OF CENTRAL PARK

By GEOFFREY CARLETON

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GEOFFREY CARLETON

New York
1 9 4 6

Birds of Central Park

By Geoffrey Carleton

Central Park in New York City is an area of particular interest to bird lovers. It is surrounded by the largest, most complex city in the world, and yet is a haven and stopping-off place for a great variety of birds which migrate over northeastern United States. It is easily worked, and its accessibility makes it excellent for beginners and experts alike. Strangely enough, Central Park is one of the best places within a radius of fifty miles of New York City to observe warblers and other insect-eating birds. As a spot for consistent observation of birds over half a century, it has scarcely been surpassed anywhere in the United States.

Many birds which breed in surrounding areas use Central Park as a stop-over station in their migratory flights. For such birds, spring departure and fall arrival dates are obtainable. To a lesser extent, fall departure and spring arrival dates are available for species that are winter visitants in the near-by regions. These latter dates are usually attributed to migration for those species rather than to casual wandering. In localities near the edge of the city it is not unusual to find a casual wanderer now and then in the breeding season and in winter.

Central Park has changed little physically through the years. As the city spread out on all sides, it was only natural that the character of the park as an oasis for migrating and resident birds should be intensified. The number of breeding and wintering species declined up to about 1923 because an increasing number of people used the park, and the landscaping was allowed to deteriorate. In the 1930's, however, some of the old shrubbery was replaced and some new plantings made. This resulted in an increase of native breeding species. In 1908, for example, there were twenty-two species that bred in the park. In 1922, they had decreased to eight; and in the 1940's, the number was back up to about a dozen. Compare this to the remarkable total of sixty-eight summer and permanent residents reported in 1886. (1).

The Ramble, the most secluded area of Central Park, is the best place for observing night-migrating insect-eating species, because it has a great variety of trees and shrubs. The wooded section in the northwest corner of the park is good for the more rural species and serves as an excellent place for winter observations. Unfortunately it has received less attention than it deserves. The Sheep Meadow, although not much more than a huge lawn, has provided many records of open country birds like the Horned Lark, the Pipit, the Meadowlark, and the Vesper Sparrow. Most of the water-fowl and gull records come from the Reservoir. All of these areas are indicated on the map of Central Park in this pamphlet.

There is an increasing tendency on the part of bird-watchers to record weather data such as extremes of temperature, wind direction and velocity, and degrees of cloudiness, for the day the observations are made. Much of this information may be found in the newspapers, along with weather maps for the entire United States. When weather data are recorded, however, both the day and night before should be included, as well as the day of observation.

A new emphasis in bird studies of this kind is being put on counting the total number of individuals observed, as well as the various species. A comparison of bird counts in successive seasons makes a fascinating study, particularly if the observer has well-established routes which he follows, and takes approximately the same number of trips each year. The author has found it convenient to keep records of his regular trips in a loose-leaf notebook with 8½″ x 11″ graph paper filler. The birds

reasonably expected in a year (about 130) are listed down the left side in taxonomic order, with dates of each trip along the top. The total number of individuals for each species is recorded in the appropriate square. Rare and unexpected species may be added at the bottom of the list when they are seen. Individuals which are suspected of lingering from previous days are not included in subsequent totals, and their continued presence may be indicated by drawing a line across that square. Another method is to record the total individuals for a single date on a printed card, such as the Urner-Edwards Field Card, on which there is also space for weather, and other notes. Urner (3) also has a statistical method of dealing with totals of individuals by seasons.

The comprehensive list of birds given here is intended as a permanent record of all observations made of birds in Central Park. It combines all the data available up through the spring of 1946, including the work of Ludlow Griscom, reported in his *Birds of the New York City Region* (2). It will also serve to show students what future observations ought to be reported in writing to the recording secretary of the Linnaean Society of New York, and to the editor of the Season, in the Audubon Magazine, because of their record-breaking nature.

Extreme dates of occurrence in a small area like Central Park are, in general, less accidental than the extreme dates for the New York City region as a whole. Second best dates are included in this list when such dates are considerably apart from the extreme. A few conclusions have been drawn by the author, but for the most part, students are left to draw their own conclusions from the data presented. Dates of average occurrence are omitted in most cases, since they are well discussed in Allan D. Cruickshank's book, *Birds Around New York City* (1). Data on breeding which occurred before the publication of Griscom's book (2) are omitted here.

There is a total of 225 species in this list. Of these, 217 are native species, one is an extirpated species (Bob-white), three are subspecies (Kumlien's Gull, Yellow Palm Warbler, and Bronzed Grackle), three are introduced species (Starling, English Sparrow, and European Goldfinch), and one is a hybrid (Brewster's Warbler). Scientific names have been omitted since the nomenclature of Cruickshank's book (1) is followed.

The record for the greatest number of species observed in a single day is seventy-eight on May 10, 1927. Twenty-four species of warblers alone were seen on May 14, 1944, including Prothonotary, Cape May, Bay-breasted, Chat, and Hooded. The largest Christmas census taken in the park comprised twenty-four species on December 30, 1945.

Data of special interest and a short bibliography follow the annotated list.

Table 1 is a statistical record of individuals observed during five fall seasons. These figures were compiled from totals of individuals observed by the author in each of the five fall seasons indicated during approximately fifteen trips which averaged an hour and a half each, during the months August through October. No comparable data are available for *spring* migrations. Here is an unusual opportunity for someone to make similar observations for spring migrations in Central Park by taking regularly scheduled trips. Such records would be useful today because they would prove a means of comparing figures for spring and fall migrations. They would also be valuable in thirty or forty years for bird-watchers who might want figures for comparisons of former years. In this way, a close check could be kept of the bird population of Central Park from year to year.

ANNOTATED LIST OF BIRDS of CENTRAL PARK

COMMON LOON — About twenty records, mostly single birds flying over: March 14, 1935 (Cruickshank) and April 12, 1938 (Cantor) to May 11, 1940 (Carleton); September 27, 1936 (Cantor); December 23, 1945 to January 5, 1946 (Carleton).

RED-THROATED LOON — One record, a bird on the Reservoir: February 28 to March 27, 1942 (Carleton, M. L. Johnson).

HOLBOELL'S GREBE — Two records, on the Reservoir: March 13 to 18, 1940 (Bull, Cantor, Carleton); April 6 to 11, 1916 (Hix, L. N. Nichols).

HORNED GREBE — Six records: December 25, 1919 (L. N. Nichols) to March 7, 1939 (Peterson) and April 29, 1937 (M. L. Johnson, Dale).

PIED-BILLED GREBE — Observed once every several years. April 11, 1914 (Hix) to April 21, 1914 (Griscom); September 9, 1941 (M. L. Johnson) to November 6, 1904 (Hix).

DOUBLE-CRESTED CORMORANT — Two records: May 6, 1941 (Rich); August 2, 1934 (Helmuth).

GREAT BLUE HERON — Seven records: March 14, 1935 (Cruickshank) to May 17, 1917 (L. N. Nichols); August 9, 1915 (Hix) to September 5, 1936 (Cantor).

EASTERN GREEN HERON — Several transients seen every season. April 19, 1933 (Rich) to May 29, 1909 (Griscom); July 29, 1941 (Carleton) to October 8, 1931 (Watson).

BLACK-CROWNED NIGHT HERON — Fairly common transient, less frequent in summer. March 19, 1938 (Rich) to November 17, 1945 (Carleton).

YELLOW-CROWNED NIGHT HERON — Five records: April 23, 1926 (fifty observers); June 20, 1937 (Lester Walsh); September 2, 1930 (Watson) to September 25, 1931 (J. T. Nichols, Watson).

AMERICAN BITTERN — Seen about every other spring. March 31, 1938 (Sedwitz) to May 17, 1917 (Janvrin). Three fall records: August 29, 1934 (Carleton) to September 23, 1926 (C. Johnston). The birds are usually flying around, occasionally perched high in trees.

CANADA GOOSE — There are about half a dozen records of flocks of wild birds flying over and out of the park, sometimes honking. March 28, 1945 (Murphy) to May 18, 1900 (Chubb); October 10, 1943 (Weingraff) to November 21, 1918 (Chubb).

BLACK DUCK — The introduced park residents number only a few dozen. These are augmented in winter by several hundred undoubtedly wild birds, which concentrate especially on the Reservoir and 59th Street pond and become quite tame. Before and after dusk flocks fly north out of the park; they have been seen flying over the Hudson, northwest in the direction of Overpeck Creek (Dale, Carleton), and north over the George Washington Bridge, possibly to Piermont or Croton (Wiegmann). For the question of races the reader is referred to Cruickshank's *Birds Around New York City;* red-legged birds are frequently seen in the park. The matter is complicated by the possibility that some introduced birds or their descendants go elsewhere during the warmer months.

BALDPATE — From time to time birds have been introduced; they have usually been wing-clipped and put on the 59th Street pond. Apparently wild birds have been seen March 2, 1946, on the Reservoir (Carleton); October 28 to November 3, 1931, the Lake (Sedwitz, Watson); November 12, 1945, the Lake (Carleton).

AMERICAN PINTAIL — In the 1930's some Pintails were introduced and stayed on the 59th Street pond. Five birds on the Reservoir after a cold wave, January 24, 1942 (Carleton) are considered wild by the author and several colleagues, as are nine Pintails flying over the Ramble, September 30, 1936 (Bull).

EUROPEAN TEAL — Male, Reservoir, January 12, 1947 (Aronoff, Schmidt).

GREEN-WINGED TEAL — Birds have occasionally been put on the 59th Street pond. Reports of wild birds are: seven, March 22, 1935 (Cruickshank); a pair, October 26, 1923 (Griscom); four, December 27, 1946 (Carleton).

BLUE-WINGED TEAL — Lake, September 5, 1942 (Stephenson, Hines); 103rd Street Pond, fall (Eisenmann); Reservoir, January 8, 12, 21, 1947 (Aronoff, Carleton).

SHOVELLER — This species has appeared on the 59th Street pond almost annually for the last nine years, dates ranging from November 15, 1941 (M. L. Johnson) to April 18, 1943 (Cantor). Three females stayed on this pond from January 11 to February 18, 1938 (Cantor). Most probably the same three females were seen further north in the park January 3, 1938 after a cold snap (Cantor). It is the consensus that these were all wild birds.

WOOD DUCK — Griscom lists four records early in this century: May 6, 1910 (Griscom); September 21, 1904 (Bildersee) to October 8, 1917 (Hix). In recent years it has been unsuccessfully attempted to breed Wood Ducks in the 59th Street Sanctuary. These birds have frequently flown over the park, and there appears to be no authentic recent records of wild birds.

REDHEAD — Two records, on the Reservoir: January 1, 1903 (Rogers); February 23-24, 1946 (Carleton, Sedwitz).

RING-NECKED DUCK — Two records, both males: February 13, 1940, on the Reservoir (Cantor et al); March 29 to April 2, 1941, on the Lake (Sedwitz).

CANVAS-BACK — Two records: a male, March 10, 1934 (Carleton); two males, December 23, 1945 (Carleton); both records on the Reservoir.

GREATER SCAUP DUCK — In recent years a frequent winter visitant, usually on the Reservoir, where flocks of as many as fifty birds have gathered. November 28, 1929 (Rogers) to April 29, 1940 (Carleton).

LESSER SCAUP DUCK — One record: a male on the Reservoir January 24, 1942 (Carleton, M. L. Johnson). The bird was at close range, the purple head and dark flanks were carefully observed in sunlight, and the wing-stripe was checked several times as the bird fanned the air.

AMERICAN GOLDEN-EYE — Three records: November 28, 1929 (Rogers) to January 27, 1946 (Carleton).

BUFFLE-HEAD — One record: a male on the Reservoir, November 12, 1945 (Carleton).

RUDDY DUCK — Four records: on the Lake, September 28 to October 1, 1934 (Carleton, Cantor); Reservoir, October 30, 1911 (Griscom, Hix); November 24, 1924 (C. Johnston); Lake, November 28-29, 1929 (Rogers).

HOODED MERGANSER — One record: November 17 to 23, 1921 (Griscom, L. Williams).

AMERICAN MERGANSER — Frequent winter visitant, as many as 140 observed at one time on the Reservoir. November 10, 1930 (Cruickshank) and December 23, 1945 (Carleton) to April 10, 1916 (L. N. Nichols) and April 29, 1940 (Carleton).

RED-BREASTED MERGANSER — About half a dozen records on the Reservoir: October 25, 1909 (Hix); January 20, 1936 (Carleton); April 1, 1938 (Cantor) to April 25, 1940 (Cantor, Carleton).

TURKEY VULTURE — Seven records: April 22, 1926 (Griscom) ; May 6, 1946 (Cantor, Weingraff) ; August 25, 1936 (Cantor) to October 28, 1934 (Breslau, Carleton, Sedwitz) and December 24, 1941 (Carleton).

SHARP-SHINNED HAWK — A transient, occurring about every other spring, fairly common in fall. April 8, 1909 (Crolius) to May 16, 1917 (Janvrin) ; August 15, 1913 (Griscom) to December 25, 1906 (Rogers) ; February 5, 1909 (Griscom). Rare after October.

COOPER'S HAWK — Seen about every two years. March 22, 1935 (Cruickshank) to May 17, 1917 (Janvrin) ; September 5, 1942 (Stephenson) to November 7, 1904 (Hix).

EASTERN RED-TAILED HAWK — Recorded from September 24, 1908 (Griscom) to January 15, 1940 (Peterson et al), but there are only three or four records since 1910.

NORTHERN RED-SHOULDERED HAWK — Recorded from March 23, 1935 (Cruickshank) to April 20, 1913 (Crolius) ; September 26, 1905 (Hix) to December 24, 1908 (Crolius), but in the last 25 years there are only about five records.

BROAD-WINGED HAWK — A transient, seen about once in five years. April 21, 1931 (Cruickshank) to May 22, 1925 (Griscom) ; August 24, 1942 (Carleton) to September 27, 1905 (Hix). Hundreds were seen overhead September 23, 1905 (Chubb).

AMERICAN ROUGH-LEGGED HAWK — One record, October 31, 1914 (J. T. Nichols).

BALD EAGLE — Three modern records. An immature bird May 5, 1938 (Cantor) ; May 19, 1926 (Crosby, Griscom) ; February 8, 1909 (Griscom). Cruickshank, in his *Birds Around New York City,* explains that there are late spring flights of young birds from the southern states.

MARSH HAWK — Three records in this century: May 15, 1906 (Hix) ; September 5, 1940 (Carleton) ; September 6, 1939 (Cantor, Carleton).

OSPREY — Seen flying over almost every year. April 5, 1913 (Crolius) to May 27, 1920 (Griscom) ; August 28, 1941 (Carleton) to October 18, 1922 (Griscom).

DUCK HAWK — Occurs at all times of the year.

PIGEON HAWK — Rare transient, often erroneously reported, probably occurs every two or three years at present. April 21, 1946 (Carleton) to May 6, 1901 (Chubb) ; September 11, 1940 (Dale) to October 13, 1925 (Watson) and October 25, 1928 (DuMont, Watson).

EASTERN SPARROW HAWK — Permanent resident, not more than two or three usually seen in a day.

BOB-WHITE — Resident until 1893.

NORTHERN CLAPPER RAIL — One record, a bird around the Azalea Pond in the Ramble May 23, 1930 (Rich, Sedwitz). It was seen pulling a worm from the ground.

VIRGINIA RAIL — One record: May 18 to 25, 1935 (Rich).

SORA — Three records: April 23, 1937 (Rich) ; August 17, 1935 (Rich) ; September 10, 1931 (Cruickshank).

PURPLE GALLINULE — One record: a bird at the Harlem Meer June 19, 1928 which lingered for several days (Carter, DuMont, Kessler, J. T. Nichols et al.). An accidental visitant from the south.

AMERICAN COOT — One modern record: November 12, 1931 (A. R. Brand).

SEMIPALMATED PLOVER — Casual, May 29, 1934 (Rich) ; September 9 and 18, 1931 (Watson, Berliner).

KILLDEER — Eight records: March 13, 1935 (Cruickshank) to May 9, 1943 (Cantor); September 3, 1884 (E. T. Adney); January 19, 1932 (Cruickshank); also February 24, 1933, perhaps an early migrant (Rich).

BLACK-BELLIED PLOVER — One record: flying overhead May 4, 1935 (Cruickshank).

WOODCOCK — A transient, seen at least once a year, often the last week of March. February 24, 1935 (Cobb) and March 8, 1942 (M. L. Johnson) to May 22, 1927 (E. A. Capen); August 11 and 23, 1936 (M. L. Johnson) to November 14, 1939 (Carleton) and December 27, 1909 (Rogers).

WILSON'S SNIPE — Eleven records: March 23, 1935 (Rich) to May 8, 1940 (Cantor); September 10, 1931 (Cruickshank) to November 7, 1935 (Birckhead).

SPOTTED SANDPIPER — Regular transient, one or two every season. April 15, 1941 (Rich) to May 30, 1901 (Chubb); July 26, 1938 (Cantor) to October 13, 1925 (Watson).

EASTERN SOLITARY SANDPIPER — Less regular than the Spotted. April 26, 1912 (Crolius, LaDow) to May 25, 1909 (Griscom); August 4, 1910 (Hix) to October 10, 1911 (Griscom) and November 1, 1903 (Hix).

GREATER YELLOW-LEGS — About ten definite records: April 28, 1933 (Rich) to May 9, 1915 (Hix); November 1, 1940 (Cantor); November 4, 1945 (Carleton).

PECTORAL SANDPIPER — Casual, September 9 to 11, 1931 (Watson, B. Berliner).

LEAST SANDPIPER — Casual, May 9, 1943 (Cantor); May 12 and 16, 1931 (Watson); May 16, 1923 (Griscom).

SEMIPALMATED SANDPIPER — About six records: May 15, 1930 (Sedwitz) to May 29, 1934 (Rich); August 9, 1930 (C. Johnston) to September 12, 1931 (Sedwitz).

WESTERN SANDPIPER — Casual, September 1 to 18, 1931, total of three birds (Watson et al.).

GLAUCOUS GULL — Three records: January 18, 1945 (Dale); March 14, 1939 (Cantor); March 24, 1927 (Griscom).

ICELAND GULL — Two records: March 8, 1927 (Watson); March 29, 1912 (Griscom, LaDow).

KUMLIEN'S GULL — This rare visitant, now classified *Larus leucopterus kumlieni,* has been carefully identified twice in the park: February 22, 1946 (Dale); March 9, 1927 (Watson, J. T. Nichols).

GREAT BLACK-BACKED GULL — Regular winter visitant, as many as 31 birds in one day in severe weather. November 19, 1946 (Carleton) to March 27, 1940 (Carleton).

HERRING GULL — Abundant winter visitant, occasional in summer.

RING-BILLED GULL — Surprisingly rare: several records of adult birds very carefully observed. September 16, 1944 (Bull) to November 19, 1946 (Carleton); May 8, 1946 (Carleton).

LAUGHING GULL — Abundant transient, occasional in summer. March 27, 1945 (Carleton) to November 24, 1931 (Brand, Watson).

COMMON TERN — Three records: May 21, 1937 (Rich); August 22, 1922 (Griscom); September 15, 1926 (Griscom).

EASTERN MOURNING DOVE — Recorded almost every spring and fall. March 26, 1905 (Hix) to June 6, 1907 (Chubb); July 26, 1927 (DuMont) to November 10, 1940 (Carleton).

YELLOW-BILLED CUCKOO — Uncommon transient, seen nearly every year. Arrival April 30, 1946 (Jacobson), no good spring departure date; August 1, 1941 (Carleton) to October 3, 1910 (Hix).

BLACK-BILLED CUCKOO — Uncommon transient, seen every year. May 4, 1944 (E. Rich) to May 27, 1926 (Griscom, Watson); occasional in summer; August 4, 1936 (Cantor) to September 27, 1905 (Hix).

EASTERN SCREECH OWL — Seen almost every year. No summer records in recent years.

GREAT HORNED OWL — Seven records: October 12, 1926 (C. Johnston) and November 7, 1943 (Eisenmann, M. L. Johnson) to April 11, 1927 (Mark Hyman, Jr.).

SNOWY OWL — One record: mid-December 1890 (L. S. Foster).

NORTHERN BARRED OWL — Four spring records: March 26, 1944 (Weingraff) to April 27, 1926 (Griscom). A bird stayed from November 20, 1939 to January 8, 1940 (R. Allen, M. L. Johnson, Rich); there are two December records in other years.

LONG-EARED OWL — Ten records: October 1, 1940 (Carleton, Dale) and November 10, 1904 (Chubb) to March 25, 1945 (M. L. Johnson) and April 24, 1922 (Janvrin et al.).

SHORT-EARED OWL — Three records: April 29, 1931 (R. Edge); September 27, 1936 (Cantor); October 5, 1934 (Carleton). The fall records were of birds flying over; information is lacking on the April record.

SAW-WHET OWL — Six records: November 5, 1918 (Albert Pinkus) to March 10, 1944 (M. L. Johnson).

EASTERN WHIP-POOR-WILL — Seen almost every spring, April 16, 1944 (E. Rich) to May 24, 1939 (M. L. Johnson). The fall records are: August 29, 1934 (Carleton); September 13, 1927 (Watson); October 5 to 7, 1935 (Birckhead, E. Petersen); October 7, 1916 (Hix); October 20, 1941, (Carleton).

EASTERN NIGHTHAWK — This bird is no longer present during the breeding season, and occurs only every two or three years as a transient. Earliest spring arrival May 6, 1932 (Cruickshank); fall dates are from August 24, 1936 (Cantor) to October 10, 1911 (Hix).

CHIMNEY SWIFT — Present in summer: April 19, 1914 (Griscom) to September 13, 1937 (Carleton).

RUBY-THROATED HUMMINGBIRD — Uncommon transient, one or two seen every year. May 4, 1904 (Hix) to May 28, 1940 (Carleton) and June 7, 1945 (M. L. Johnson et. al.); August 6, 1942 (Carleton) to September 22, 1921 (Griscom) and October 2, 1927 (Griscom).

EASTERN BELTED KINGFISHER — Several transients seen each spring and fall; March 4, 1935 and March 20, 1937 (Rich) to June 3, 1941 (Carleton); July 12, 1942 (M. L. Johnson) to October 21, 1907 (Griscom). There are several July records, and this species is undoubtedly the earliest transient to reach the park in the fall.

NORTHERN FLICKER — Common transient, several pairs breeding. There are at least six winter records.

RED-BELLIED WOODPECKER — An accidental visitant from the south. April 30 and May 1, 1909 (Griscom).

RED-HEADED WOODPECKER — Erratic transient, occurring about every other year. March 24, 1914 (Hix) to March 31, 1910 (Crolius); May 6, 1932 (Rich) to May 18, 1934 (Rich, Sedwitz); September 4, 1940 (Carleton) to October 24, 1907 (Griscom).

YELLOW-BELLIED SAPSUCKER — Fairly common transient: March 21, 1926 (Mrs. Mead) to May 16, 1933 (Rich); casual July 1, 1909 (Crolius); September 19, 1914 (Hix) to November 12, 1932 (Carleton).

EASTERN HAIRY WOODPECKER — A winter visitant, one or two usually wintering at the north end. September 22, 1925 (Hickey) to May 20, 1919 (Granger, Griscom).

NORTHERN DOWNY WOODPECKER — Permanent resident, two or three pairs. Griscom records transients October 6, 1910 to October 30, 1911.

KINGBIRD — A transient, varying from two or so to about fifteen a season: April 23, 1920 (Griscom, Miss E. H. McVickar) and April 29, 1942 (Rich) to May 30, 1906 (Hix); casual June 26, 1937 (Carleton); August 3, 1937 (Carleton) to October 1, 1934 (Cantor).

NORTHERN CRESTED FLYCATCHER — Several transients each season. April 27, 1925 (Mrs. Mead) to June 13, 1927 (Eaton); casual July 7, 1926 (C. Johnston); August 2, 1903 (Griscom) to October 1, 1934 (Cantor).

EASTERN PHOEBE — Common transient: March 10, 1909 (Griscom) to late April and May 7, 1909 (Griscom); September 3, 1916 (Janvrin) to November 4, 1917 (Hix).

YELLOW-BELLIED FLYCATCHER — Two or three each spring, about six each fall: May 13, 1942 (Carleton) to June 7, 1945 (M. L. Johnson); August 1, 1941 (Weingraff) and August 9, 1923 (Griscom) to September 30, 1931 (Watson).

ACADIAN FLYCATCHER — Only one authentic record in the last thirty years based on a singing bird: May 8, 1935 (Cruickshank and R. Kuerzi).

ALDER FLYCATCHER — Three records based on singing birds: May 13, 1942 (Murphy); May 21, 1934 (Cruickshank, E. Rich); early June, about 1904 (Crolius).

LEAST FLYCATCHER — Fairly common transient. April 25, 1939 (Carleton) to May 29, 1907 (Griscom). Small flycatchers recorded from August 11, 1913 (Griscom) to October 1, 1903 (Hix) are unquestionably mostly this species; singing birds were identified September 3, 1941 (Carleton) and September 7, 1934 (Carleton).

EASTERN WOOD PEWEE — Common transient, usually present in breeding season. May 4, 1905 (Hix) to October 2, 1934 (Carleton), October 21, 1907 (Crolius, Griscom) and October 29, 1927 (Watson, DuMont).

OLIVE-SIDED FLYCATCHER — Observed on about two out of three springs, more regular in fall; usually only one bird per season. May 10, 1922 (Griscom) to June 6, 1941 (Weingraff); August 3, 1937 (Carleton) to September 21, 1931 (Cruickshank) and October 2, 1928 (DuMont).

NORTHERN HORNED LARK — Flocks seen four times: October 28, 1932 (Carleton) to November 24, 1928 (Cruickshank), the birds carefully studied and apparently all this subspecies.

TREE SWALLOW — Fairly common transient, probably not seen every year. April 16, 1911 (Hix) to June 3, 1907 (Hix); July 26, 1938 (Cantor) to November 3, 1926 (Griscom, Watson) and November 23, 1933 (Cruickshank). Usually flying high.

BANK SWALLOW — Griscom's book lists transients from April 29, 1912 (Griscom) to May 30, 1917 (Hix); three records from August 10, 1911 (Hix) to August 26, 1904 (Hix). There are only one or two records since then.

ROUGH-WINGED SWALLOW — Two positive records: May 2, 1939 (Sedwitz); May 3, 1917 (Hix).

BARN SWALLOW — Recorded annually, several individuals or small flocks flying overhead. April 16, 1911 (Hix) to June 3, 1907 (Hix); July 11, 1935 (Cantor) and July 26, 1938 (Cantor) to September 28, 1910 (Griscom).

NORTHERN CLIFF SWALLOW — Griscom's book lists transients from April 20, 1911 (Griscom) to June 3, 1907 (Hix). There are only two records since then, in the 1940's in early May.

PURPLE MARTIN — Six spring records: April 12, 1932 (Cruickshank) to May 13, 1907 (Hix); once in fall, August 23, 1915 (Hix).

BLUE JAY — Common transient, quite variable in numbers, usually about five to fifteen individuals in a season; hundreds reported September 30, 1935 (Knoblauch). Arrives about every other year in April. April 17, 1941 (Rich) to June 6, 1917 (Hix); a pair

made an unsuccessful attempt to breed in 1945 (Eisenmann); August 31, 1914 (Hix) to November 16, 1907 (Griscom); two December records (Carleton); March 7, 1939 (Cantor).

EASTERN CROW — Griscom lists dates from March 8, 1904 (Hix) to May 9, 1919 (Griscom), most frequent the last half of April; September 26, 1914 (Hix) to November 10, 1912 (Griscom). Though safely identified by call only, it is undoubtedly a rare transient now.

FISH CROW — Spring transient, occurring almost every year. March 2, 1932 (Cruickshank) and April 6, 1914 (Hix) to June 11, 1901 (Chubb).

BLACK-CAPPED CHICKADEE — Regular winter visitant, as many as twelve in one day. September 18, 1941 (Carleton) to May 5, 1940 (Eisenmann).

TUFTED TITMOUSE — Two records; one present for two weeks in May, 1908 (Crolius); August 14, 1937 (Stephenson).

NORTHERN WHITE-BREASTED NUTHATCH — Recorded almost every year as a transient; a bird or two frequently seen in winter uptown. September 11, 1913 (Hix) to May 9, 1907 (Chubb).

RED-BREASTED NUTHATCH — Irregular transient, a bird or two seen about every two years in early May, about four seen every fall in recent years; less regular before 1937. August 16, 1906 (Hix) and August 27, 1939 (Carleton) to November 17, 1931 (Carleton); April 22, 1946 (Carleton) to May 24 and June 4, 1917 (Hix) and June and July, 1892 (F. M. Chapman). Last wintered in 1923-24 (Mrs. Mead).

BROWN CREEPER — Common transient, March 24, 1945 (M. L. Johnson) to May 21, 1917 (Hix); September 9, 1913 (Hix) to November 30, 1907 (Griscom).

HOUSE WREN — A transient, several individuals each spring, usually one each fall; April 21, 1941 (Sedwitz) to May 17, 1921 (Griscom) and June 3, 1941 (Carleton); bred in 1935 (Rich); September 15, 1937 (Carleton) to October 13, 1919 (L. N. Nichols) and October 27, 1945 (Carleton).

EASTERN WINTER WREN — Erratic transient, seen almost every April, varies from none to over half a dozen in fall. March 19, 1918 (Hix) to May 15, 1912 (Crolius); September 26, 1914 (Hix) to November 30, 1907 (Griscom).

BEWICK'S WREN — Accidental visitant, a singing bird from April 10 to May 8, 1928 (Miss E. A. Capen, Carter, Watson et al.)

CAROLINA WREN — Griscom records birds present from October to December 1907 (Crolius); June, 1908 to February, 1909. The only recent records are: September 18 (Eisenmann) and December 7 (G. Morgan) 1925; April 25, 1932 (Holgate); October 19, 1933 (M. L. Johnson); September 17, 1944, a singing bird (Weingraff).

LONG-BILLED MARSH WREN — Now seen about every two out of three years. May 1, 1942 (Murphy) to May 18, 1934 (Cruickshank); September 22, 1945 (Carleton).

SHORT-BILLED MARSH WREN — Two records: a singing bird in the old reservoir fill July 13, 1931 (Watson); October 4, 1943 (J. T. Nichols).

MOCKINGBIRD — Erratic visitant, nine records. On three occasions it has remained several weeks to three months. August 27, 1921 (Griscom) to November 15, 1927 (Watson, DuMont) and January 20, 1893 (F. M. Chapman); March 15 to April 3, 1928 (Miss E. A. Capen, DuMont, Watson); June 8, 1939 (Weingraff).

CATBIRD — Common transient; in the mid-1930's resumed breeding, now several pairs, April 21, 1941 (J. T. Nichols, H. C. Raven) to October 23, 1932 (Carleton).

BROWN THRASHER — Common transient, has bred several times in the last ten years. April 15, 1936 (Carleton) to October 26, 1932 (Carleton); wintered 1938-39 (L. N. Nichols, Dale), the first time since 1910.

EASTERN ROBIN — Abundant summer resident, occasional in winter.

WOOD THRUSH — Uncommon transient, two or three seen every spring and fall. April 27, 1925 (Curtiss) to May 26, 1945 (Carleton); August 24, 1942 (Carleton) to October 7, 1935 (Cantor); occasionally breeding in the last ten years.

EASTERN HERMIT THRUSH — Common transient. March 23, 1945 (J. T. Nichols) to May 16, 1907 (Chubb), May 25, 1925 (Watson), May 29, 1940 (Stephenson) and June 6, 1928 (E. A. Capen, Watson); September 22, 1927 (Watson) to December 1, 1945 (Carleton); casual in winter.

OLIVE-BACKED THRUSH — Very common transient. April 28, 1938 (Sedwitz) to June 9, 1945 (Carleton); August 28, 1937 (Carleton) to October 20, 1934 (Mayer) and October 30, 1936 (Carleton).

GRAY-CHEEKED THRUSH — Common transient. May 5, 1926 (Griscom) to June 7, 1945 (Carleton, M. L. Johnson); September 9, 1938 (Carleton) to October 23, 1932 (Carleton).

VEERY — Common transient. April 25, 1939 (Cantor) to May 30, 1907 (Griscom); August 20, 1915 (Hix) to September 22, 1939 (Carleton).

EASTERN BLUEBIRD — Irregular transient, seen in about three out of five seasons. March 10, 1939 (Rich) to May 19, 1926 (C. Johnston); October 20, 1941 (Carleton) to November 22, 1941 (Carleton) and December 15, 1901 (Rogers); February 12, 1938 (Rich).

BLUE-GRAY GNATCATCHER — Recorded about every two out of three springs, one out of three falls. April 4, 1945 (Murphy) to May 24, 1920 (Griscom); August 4, 1939 (Cantor, Norse) to October 8, 1935 (M. L. Johnson).

GOLDEN-CROWNED KINGLET — Fairly common spring, common fall transient. March 20, 1945 (M. L. Johnson) to May 3, 1914 (Hix); September 23, 1942 (M. L. Johnson) to November 27, 1931 (Carleton). I find no winter records for the last 25 years.

EASTERN RUBY-CROWNED KINGLET — Common transient. March 31, 1910 (Crolius) to May 16, 1910 (Griscom); September 15, 1913 (Hix) to November 11, 1939 (Carleton).

AMERICAN PIPIT — Seven records: May 5, 1919 (Griscom); October 21, 1933 (Carleton) to October 31, 1909 (Crolius); December 25, 1919 (L. N. Nichols); February 16, 1932 (Cruickshank).

CEDAR WAXWING — Uncommon late spring transient, May 4, 1906 (Hix) to June 3, 1901 (Chubb); common fall transient, flocks often present among the cherry trees from the beginning of August into October; July 26, 1935 (Cantor) to November 14, 1915 (Hix). Vagrant flocks have shown up as follows: February 9, 1939 (Cantor); March 12, 1905 (Hix); March 24, 1942 (M. L. Johnson); April 11, 1941 (Carleton); April 28, 1917 (Janvrin).

NORTHERN SHRIKE — Eight records, none since 1927. November 2, 1904 (Hix) to April 14, 1922 (Griscom).

MIGRANT SHRIKE — Four records of carefully studied birds: April 6, 1932 (Carleton); April 11, 1939 (Cantor); May 10, 1943 (L. N. Nichols); September 15, 1910 (Hix).

STARLING — Abundant permanent resident in this locality where it was first successfully introduced, in 1890. Hundreds pour in in winter to the park as a whole, in addition to several thousand that have used the Metropolitan Museum of Art as a winter roost certain recent years.

WHITE-EYED VIREO — Rare spring transient, not seen every year: April 27, 1938 (Cantor, Dale) to May 23, 1909 (Griscom) and May 30, 1939 (Sedwitz); very rare in fall, September 23, 1900 (Hix) to October 8, 1925 (Crosby, Watson).

YELLOW-THROATED VIREO — Seen almost every spring, April 30, 1940 (Carleton, Dale) to May 23, 1938 (Cantor). Up till thirty years ago recorded in fall, up to September 28, 1910 (Hix).

BLUE-HEADED VIREO — Uncommon transient, from one to six usually seen a season. April 8, 1929 (Sedwitz) to May 25, 1925 (F. M. and E. A. Capen) and June 2, 1935 (Sedwitz); September 19, 1934 (Carleton) to October 28, 1930 (Watson).

RED-EYED VIREO — Common transient, twenty individuals seen a season, still present in the breeding season. May 3, 1913 (Crolius) to October 17, 1908 (Crolius).

PHILADELPHIA VIREO — There are six spring and eight fall records, all by competent observers: May 4, 1937 (Sedwitz et al.) to May 18, 1927 (Griscom) and June 1, 1927 (C. Johnston); August 29, 1930 (Carter, Watson) to September 21, 1933 (Sedwitz); casual earlier, one reported August 17, 1936 (Norse).

EASTERN WARBLING VIREO — Rare transient, April 30, 1941 (Rich) to May 19, 1926 (Griscom). Nested in 1928 (Watson) and formerly, up to 1914.

BLACK AND WHITE WARBLER — April 13, 1942 (E. Rich) and April 19, 1909 (Griscom) to May 25, 1933 (Carleton); July 29, 1941 (Carleton) to October 20, 1907 (Griscom) to November 14, 1908 (Crolius).

PROTHONOTARY WARBLER — Five records, April 29, 1926 (Alfred Hayes et al.) to May 14, 1944 (Dale).

WORM-EATING WARBLER — April 19, 1909 (Griscom, LaDow), April 27, 1925, five birds (Griscom, Curtiss) and May 6, 1914 (Griscom) to May 18, 1939 (Carleton); August 3, 1937 (Carleton) to August 30, 1940 (Carleton).

GOLDEN-WINGED WARBLER — May 2, 1928 (DuMont) to May 21, 1928 (Watson); August 2, 1937 (Carleton) to September 8, 1907 (Hix) and October 3, 1907 (Crolius).

BLUE-WINGED WARBLER — Less common in spring than fall. April 27, 1938 (Rich) to May 18, 1945 (Carleton); July 28, 1937 (Carleton) to September 8, 1941 (Carleton).

BREWSTER'S WARBLER — The following eight records are presented as a matter of information. Individuals vary a great deal, and I have seen some not clearly referable to either this or the Lawrence's; such variation is expectable in hybrids, and in the sense of a definite form with consistent characters there is really no such thing as a Brewster's Warbler. April 29, 1914 (Hix) to May 15, 1939 (Darrow).

TENNESSEE WARBLER — May 5, 1944 (M. L. Johnson) to May 28, 1937 (Rich); August 11, 1941 (Carleton) to October 11, 1925 (Baker).

ORANGE-CROWNED WARBLER — Five spring records, May 6, 1932 (Mayr, Watson) and May 13, 1926 (Griscom) to May 16, 1928 (Hix). There are several very early fall reports, which are surprising because of the remoteness of the bird's breeding range and the fact that it is usually a very late fall migrant; they are by very careful and experienced observers. August 10, 1931 (Watson, B. Berliner), on a day with unusually cold north-west winds; August 21, 1944 (Bull, Komorowski); August 22, 1930 (Carter, Watson); September 1, 1939 (Cantor, Norse). There are at least six records from September 12, 1928 (DuMont) to October 27, 1939 (Carleton); November 22, 1941 (Carleton). The identification of the immature, often seen in fall, is discussed in the Linnaean Society of N. Y. Proceedings. Nos. 52, 53, p. 137; this note has a misprint: the "end" of the wing of the Tennessee Warbler should read "Bend."

NASHVILLE WARBLER — April 21, 1919 (Hix) and April 25, 1939 (Cantor) to June 6, 1907 (Chubb); August 10, 1941 (Carleton) to October 17, 1914 (Hix), November 9 to 11, 1935 (Birckhead) and November 30, 1937 (Cantor). This species has a favorite tree, a hawthorn, in which it is seen year after year.

NORTHERN PARULA WARBLER — April 21, 1919 (Hix) to June 6, 1907 (Hix); casual June 24, 1934, a singing male (Carleton); August 12, 1911 (Hix) to October 17, 1914 (Hix).

EASTERN YELLOW WARBLER — Bred up till early 1940's. April 19, 1912 (Crolius) to September 22, 1939 (Carleton, Dale) and October 5, 1921 (Carter, Griscom).

MAGNOLIA WARBLER — April 27, 1935 (E. Eliot) and May 1, 1944 (M. L. Johnson, E. Rich) to June 11, 1907 (Chubb); August 16, 1911 (Hix) to October 22, 1940 (Cantor).

CAPE MAY WARBLER — Regular but uncommon transient in spring, less common than in fall; apparently less common than 25 years ago; much commoner than 50 years ago. May 4, 1936 (Rich) to May 24, 1909 (Griscom); August 10, 1931, cold north-west wind (Watson) and August 22, 1944 (Komorowski) to October 11, 1908 (Griscom). Ten individuals on September 3, 1944 (Bull).

BLACK-THROATED BLUE WARBLER — April 24, 1943 (E. Rich) to June 2, 1930 (Watson); August 23, 1905 (Hix) to October 22, 1940 (Cantor).

MYRTLE WARBLER — March 17, 1927 (G. Morgan) and April 4, 1910 (Griscom) to May 28, 1940 (Carleton); August 19, 1922 (Griscom) to November 22, 1941 (Carleton). There are seven August records.

BLACK-THROATED GREEN WARBLER — April 9, 1908 (Crolius, Griscom) and April 19, 1924 (Linnaean Society) to June 6, 1907 (Chubb) and June 13, 1940 (Carleton); August 24, 1935 (Cantor) to October 24, 1907 (Griscom). Casual December 3, 1946 (Carleton).

CERULEAN WARBLER — Five records: May 5, 1885 (Dutcher); May 11, 1927 (Griscom et al.); May 18, 1938 (Pangburn); August 3 to 6, 1937 (Carleton, Stephenson); September 15, 1923 (Boulton).

BLACKBURNIAN WARBLER — April 27, 1943 (Dale, M. L. Johnson) and April 30, 1942 (Dale) to June 7, 1907 (Hix); August 3, 1908 (Griscom) to October 8, 1906 (Hix).

YELLOW-THROATED WARBLER — Three records: April 17-18, 1919 (E. Eliot et al.); April 23, 1943 (E. Rich, Dale, J. T. Nichols et al.); April 29 to May 1, 1926 (Alfred Hayes and many others). These birds are not clearly referable to the southern race. The first bird was found dead April 18, and after some years the specimen was received by the American Museum of Natural History; it superficially resembles the western race (*albilora*) in that the lores are white, but other points suggest the southern race (*dominica*), some specimens of which, furthermore, have white lores; Tousey and Griscom found in 1937 (Auk, v. 54, p. 210) that the two available New England specimens were *albilora;* while this suggests the possibility that the Central Park birds were *albilora,* identifications are very difficult, or inconclusive. The 1943 bird resembled the 1919 specimen (J. T. Nichols); the 1926 bird was apparently not subspecifically determined or determinable. It would be advisable to have a popular name for the whole species such as "Song Sparrow," for use in all cases in which the subspecies is not identifiable in the field a/o is assumed by range only.

CHESTNUT-SIDED WARBLER — April 26, 1939 (Rich) to May 30, 1907 (Chubb) and June 7, 1945 (M. L. Johnson); casual June 26, 1901 (Chubb); July 30, 1940 (Weingraff) to October 2, 1939 (Carleton).

BAY-BREASTED WARBLER — Several usually seen every spring, apparently about as common as in 1900 though less common than in 1920 and adjoining years. May 2, 1932 (Cruickshank, M. L. Johnson) to June 7, 1907 (Hix); August 20, 1914 (Hix) to September 26, 1921 (Griscom). Fourteen individuals observed September 3, 1944 (Bull).

BLACK-POLL WARBLER — May 2, 1936 (Carleton, Rich) to June 15, 1917 (Hix); August 29, 1941, two birds carefully studied and not Bay-breasted Warblers (Carleton) to October 22, 1932 (Carleton). Usually the last spring transient to leave the park.

NORTHERN PINE WARBLER — Seen every spring, once every few years in fall. March 29, 1921 (Samek) to May 5, 1912 (Crolius); September 11, 1931 (Watson) to October 29, 1911 (Hix).

PRAIRIE WARBLER — April 25, 1928 (Watson) to June 2, 1909 (Crolius); August 14, 1936 (Cantor) to October 11, 1937 (Carleton).

WESTERN PALM WARBLER — There are less than a dozen definite records of this bird in spring. April 22, 1909 (Crolius) to May 7, 1914 (Rogers); August 28, 1941 (Carleton) to October 13, 1939 (Carleton).

YELLOW PALM WARBLER — Two or three dozen individuals are occasionally reported on one day in spring, and on April 21, 1928 over 200 (Watson et al.). March 30, 1945 (Komorowski) to May 16, 1917 (Janvrin); September 22, 1922 (Carter, Crosby, Griscom) to November 18, 1925 (E. A. Capen).

OVEN-BIRD — Very common in spring. April 25, 1917 (Janvrin) to June 7, 1945 (Carleton, M. L. Johnson); casual June 15, 1928 (Watson); July 31, 1908 (Griscom) to October 15, 1939 (Carleton) and November 2, 1931 (Cruickshank).

NORTHERN WATER-THRUSH — April 22, 1946 (Carleton) to June 7, 1945 (Carleton, M. L. Johnson); July 29, 1941 (Carleton) to October 10, 1911 (Griscom).

LOUISIANA WATER-THRUSH — Recorded about every second year in the third week of April. Though Griscom states: "rarely recorded except on the big warbler waves in May" it appears to be very rare now after the 25th of April. Pale-looking Northern Water-Thrushes or birds that are not satisfactorily determinable are constantly being reported as Louisianas. April 2, 1916 (Hix) to May 24, 1909 (Crolius); August 4, 1937 (Carleton) to October 3, 1914 (Hix); casual November 24, 1910 (Hix).

KENTUCKY WARBLER — Occurs about once in five years. May 6, 1938 (Dale) and May 12, 1899 (Crolius) to May 28, 1909 (Crolius); casual June 13, 1892 (F. M. Chapman); September 7, 1934 (Dale).

CONNECTICUT WARBLER — Casual in spring, a dozen fall records. May 15, 1912 (Crolius, Griscom, LaDow, Miller, Wiegmann); May 15, 1921 (C. Johnston); September 9, 1908 (Hix) to October 9, 1936 (Cantor).

MOURNING WARBLER — Recorded on about two out of three springs; eight individuals seen in August, 1923 (Griscom), otherwise only four fall records. May 16, 1905 (Hix) to June 8, 1945 (Carleton, E. Rich); August 6, 1908 (Griscom) to September 10, 1944 (Bull, Eisenmann).

NORTHERN YELLOW-THROAT — April 23, 1941 (R. B. Fischer, Sedwitz) to June 8, 1945 (Carleton); August 4, 1942 (Carleton) to October 28, 1926 (Griscom).

YELLOW-BREASTED CHAT — About two birds recorded every spring, only two fall records. May 3, 1938 (Carleton) to May 31, 1901 (Chubb); August 26, 1913 (Hix); October 5, 1921 (Carter, Griscom).

HOODED WARBLER — May 1, 1941 (Rich) to May 30, 1917 (Hix); August 2, 1935 (Cantor) to September 8, 1913 (Hix), September 28, 1931 (Brand, Watson) and October 3, 1939 (Carleton).

WILSON'S WARBLER — April 30, 1920 (E. Eliot); May 2, 1911 (Griscom) and May 6, 1938 (Carleton, Rich) to June 7, 1945 (M. L. Johnson); August 18, 1936 (Cantor) to October 10, 1907 (Crolius, Griscom) and October 31, 1903 (Rogers).

CANADA WARBLER —May 3, 1938 (Carleton, Rich) to June 12, 1907 (Hix); July 30, 1942 (Carleton) to September 25, 1910 (Hix) and October 8, 1907 (Crolius, Griscom).

AMERICAN REDSTART — April 27, 1938 (Carleton) to June 7, 1945 (Carleton, M. L. Johnson); July 29, 1941 (Carleton) to October 13, 1945 (Carleton); casual November 9, 1924 (F. M. Capen).

ENGLISH SPARROW — Abundant permanent resident. Anyone enthusiastic enough to comb the entire park especially for these birds would probably net well over a thousand.

BOBOLINK — Eight spring records, April 30, 1935 (Rich) to May 18, 1934 (Cruickshank); a dozen or so fall records, birds flying overhead early in the morning, calling: August 21, 1944 (Bull) to September 13, 1940 (Carleton).

EASTERN MEADOWLARK — Recorded almost annually. March 26, 1927 (Mrs. Tucker) to May 6, 1926 (Griscom) and May 22, 1935 (Rich); October 7, 1935 (Cantor) to November 8, 1930 (Morgan) and November 21, 1940 (Carleton).

EASTERN RED-WING — Fairly common transient, most of the spring records in late April or early May, long after the usual migration period. March 8, 1933 (Rich) to May 22, 1937 (Carleton); July 26, 1938 (Cantor) and August 10, 1939 (Carleton) to December 7, 1901 (Rogers); two January records.

ORCHARD ORIOLE — Rare transient, adult males appearing every few years; dull female Baltimores are frequently mistaken for this species. May 3, 1940, adult male (Carleton, M. L. Johnson) to May 25, 1904 (Hix); no fall records.

BALTIMORE ORIOLE — Common spring transient, arrival April 28, 1943 (E. Rich); no good departure date. Two or three usually seen in the fall, August 19, 1943 (M. L. Johnson) to September 21, 1909 (Griscom). Though Griscom classed it as a common summer resident, there are apparently no summer records for ten years or so preceding 1946.

RUSTY BLACKBIRD — Irregular transient, one or two records almost every season, frequent in early May. March 2, 1939 (Cantor) to May 12, 1925 (Griscom, Hix); September 27, 1904 (Hix) to November 17, 1936 (Carleton).

PURPLE GRACKLE — Common summer resident, very common spring transient, arrival February 13, 1909 (Crolius); scarce by September, but the birds have lingered to October 12, 1940 and October 18 and 29, 1941 (all Carleton). All these birds are referable to Stone's or Ridgway's Grackles or intermediates between the two, as discussed in Cruickshank's book. A bird observed in January 1932 (Carleton) resembled these.

BRONZED GRACKLE — A dozen Bronzed have been observed under most satisfactory conditions. October 26 and November 5, 1926 (Griscom, C. Johnston, Watson); November 22, 1941 (Carleton); December 30, 1945 (Carleton); January 15, 1933 (Carleton); March 1, 1914 (Hix) to April 26, 1926 (Griscom).

COWBIRD — Seen almost every year. March 13, 1935 (Rich) to May 15, 1913 (Griscom); October 6, 1911 (Hix) to November 9, 1907 (Griscom).

SCARLET TANAGER — Fairly common transient, about five seen each fall, perhaps twice that number each spring. April 27, 1925 (Curtiss) to June 4, 1907 (Hix); August 2, 1935 (Cantor) and August 14, 1937 (Carleton) to October 21, 1940 (Cantor).

SUMMER TANAGER — Three records, by very reliable observers: April 26, 1937 (Peterson); July 6, 1940 (Wiegmann); September 10, 1930 (Watson). In May 1939 a dull vermilion tanager with pale gray wings spent several days in the Ramble; the bill was pale gray. At first many thought it a Summer, but after considering, among other points, that the color was not exactly the rose of a Summer, the bird was judged an albinistic Scarlet. This shows the caution necessary in identifying casual visitants, even in the case of a bird apparently easy to tell.

EASTERN CARDINAL — Griscom states: "Formerly a common resident, extinct since 1914." In 1935 the bird reappeared, and since then has been seen frequently, though erratically, often staying some time. There are recent records for every month, a maximum of four individuals in one day. One pair seems to have established a territory since 1944, and may breed.

ROSE-BREASTED GROSBEAK — Fairly common spring transient, only one individual usually seen per fall. April 30, 1941 (E. Rich) to May 22, 1899 (Chubb) and May 30, 1942 (Carleton); September 8, 1941 (Carleton) to September 28, 1913 (Hix); casual December 16, 1909 (fide Griscom).

INDIGO BUNTING — Several seen each spring, recorded in fall about once in three years. April 18, 1935 (Rich), April 22, 1910 (Griscom, LaDow) and April 28, 1938 (Dale, M. L. Johnson) to May 25, 1939 (M. L. Johnson); September 7, 1939 (Carleton) to October 5, 1921 (Griscom).

[PAINTED BUNTING — A bird reported September 9 to 23, 1927 (Miss B. Samek, et al.). The fourth A. O. U. Check-list lists this species as breeding north to northern Mississippi and southeastern North Carolina, but not occurring further north on the Atlantic coast in the wild state. Although the cage-bird traffic had long since been stopped, the bird remained a popular zoo and aviary inmate, and recent records around New York are confined to the city. There is a fair likelihood that the bird was an escape, so as a genuine record of an accidental visitant the report seems valueless.]

DICKCISSEL — Casual, September 8 to 15, 1939 (Dale, Brooks, Peterson, Rich); October 4, 1922 (Griscom).

EASTERN PURPLE FINCH — Uncommon spring, common fall transient. September 3, 1941 (Carleton) to November 16, 1907 (Griscom); four winter records: March 25, 1939 (Rich) and April 11, 1922 (Griscom) to May 19, 1939 (Carleton); casual July 6, 1888, a (juvenal) male (Jenness Richardson).

PINE GROSBEAK — Recorded the winter of 1903-04, arriving November 12 (Rogers); November 19, 1923 (C. Johnston).

EUROPEAN GOLDFINCH — This introduced species appeared in the park in 1879 and was a common resident until some time before 1907; since then there are two records: May 9, 1920 (L. N. Nichols); September 9 to 26, 1932 (Dale, M. L. Johnson).

COMMON REDPOLL — Very rare visitant, one record in the last twenty-five years. November 10, 1901 (Rogers) to March 6, 1936 (Cantor).

PINE SISKIN — Rare visitant. October 11, 1903 (Rogers) to November 27, 1913 (Hix); wintered 1908-09, departing late in March; March 21, 1939 (Cantor); three records from May 10, 1914 (Griscom) to May 24, 1917 (Janvrin).

EASTERN GOLDFINCH — Common transient, occasional in winter. August 25, 1936 (Cantor) to May 28, 1940 (Carleton).

RED CROSSBILL — Has occurred six times, two of which it wintered; latest spring date May 12, 1887 (Jenness Richardson). No record since 1909.

WHITE-WINGED CROSSBILL — Occurred in the winter of 1899-1900 (Fide Griscom).

RED-EYED TOWHEE — Common transient. March 26, 1945 (Komorowski, J. T. Nichols) to June 4, 1943 (E. Rich); September 18, 1939 (Carleton) to November 21, 1940 (Carleton); wintered at least twice many years ago (fide Griscom).

EASTERN SAVANNAH SPARROW — Regular transient, five or ten birds usually seen every season. March 20, 1945 (J. T. Nichols) and March 30, 1935 (Cruickshank, Mayr) to May 16, 1946 (Carleton); September 16, 1904 (Hix) to November 3, 1932 (Carleton).

EASTERN GRASSHOPPER SPARROW — Casual: May 3 and 6, 1932 (Rich); May 10, 1934 (Cruickshank); early October about 1903 (Crolius).

NORTHERN SEASIDE SPARROW — One record, May 16, 1923 (Griscom et al.); purely casual in such a locality.

EASTERN VESPER SPARROW — Occurs about once in two years. April 9, 1940 (Cantor) to May 3, 1935 (Rich); October 13, 1922 (Griscom) to November 2, 1926 (C. Johnston).

EASTERN LARK SPARROW — Casual, May 10, 1946 (Gladys G. Fry), a singing bird very carefully studied.

SLATE-COLORED JUNCO — Abundant transient, common winter visitant. September 13, 1941 (Carleton) to May 16, 1917 (Janvrin). Arrivals noted March 4, 1935 (Cruickshank).

EASTERN TREE SPARROW — Uncommon visitant, occurring almost every year, especially after a heavy snow. October 29, 1941 (Carleton) to April 9, 1911 (Griscom) and April 24, 1940 (Carleton).

EASTERN CHIPPING SPARROW — Common transient, occasionally breeding, over half a dozen winter records blending into early arrival dates in March. A dozen in a flock frequent in April.

FIELD SPARROW — Common transient, frequent in winter. September 23, 1913 (Hix) to May 26, 1913 (Griscom); arrivals noted March 21, 1942 (Carleton).

WHITE-CROWNED SPARROW — Uncommon transient, several seen every spring, two or three recorded about every other fall. April 24, 1896 (L. S. Foster) to May 26, 1909 (Crolius); October 1, 1911 (Hix) to November 1, 1939 (Carleton); February 13, 1926 (Kassoy).

[GAMBEL'S SPARROW — An adult, carefully studied May 10, 1946, by Mr. Walter Sedwitz, who was previously familiar with the Nuttall's Sparrow in life, was apparently this subspecies. There have been several reports of Gambel's in the northeast in recent years, one being caught in a banding trap in April at Lititz, Pa., photographed, and released. In a case in which positive identification is so difficult however, it seems best to mention the bird tentatively.]

WHITE-THROATED SPARROW — Abundant transient, irregularly common in winter. September 15, 1910 (Hix) to May 29, 1907 (Griscom); lingered to July 2, 1907, a very cold, late spring (Chubb). Arrived April 4, 1913 (Griscom).

FOX SPARROW — Common transient, frequent in winter. October 2, 1910 (Griscom) to April 28, 1933 (Rich); casual August 9, 1913 (Griscom).

LINCOLN'S SPARROW — Regular spring transient, one or two individuals; May 2, 1911 (Wiegmann) to May 27, 1941 (Carleton, M. L. Johnson) and June 7, 1945, very carefully studied (Carleton); four fall records: September 21, 1909 (Crolius) to October 1, 1936 (Cantor).

SWAMP SPARROW — Common spring transient, surprisingly scarce in fall in the last few years, about two usually seen by one observer. March 18, 1943 (J. T. Nichols) to June 1, 1940 (Carleton); September 25, 1922 (Carter, Griscom) to November 9, 1908 (Griscom), December 24, 1930 (Cruickshank) and December 25, 1939 (Carleton).

EASTERN SONG SPARROW — Abundant transient, common winter visitant, a few pairs breeding.

LAPLAND LONGSPUR — One record, November 24, 1928 (Cruickshank).

SNOW BUNTING — Four records: October 28, 1932 (Carleton); November 10, 1936 (Carleton); March 4-5, 1905 (C. G. Abbott, Hix); March 5, 1904 (C. Schaller).

DATA OF SPECIAL INTEREST

TABLE 1. WARBLERS RANKED IN ORDER OF ABUNDANCE

Name of Warbler	Individuals by Fall Seasons					Total
	1934	1937	1939	1940	1941	
American Redstart	50	64	107	94	88	403
Black-poll Warbler	51	80	197	33	39	400
Myrtle Warbler	..... Estimated					250
Black-throated Green Warbler	16	18	59	27	35	155
Magnolia Warbler	12	16	47	12	30	117
Black and White Warbler	16	20	27	20	29	112
Northern Yellow-throat	21	23	47	12	6	109
Northern Water-Thrush	5	19	22	14	25	85
Northern Parula Warbler	5	12	20	15	10	62
Canada Warbler	12	9	8	5	26	60
Prairie Warbler	4	6	18	4	11	43
Western Palm Warbler	3	4	19	8	7	41
Blue-winged Warbler	2	14	3	8	6	33
Wilson's Warbler	3	3	14	5	6	31
Tennessee Warbler	1	1	10	8	9	29
Black-throated Blue Warbler	2	2	9	6	9	28
Chestnut-sided Warbler	2	6	11	1	7	27
Cape May Warbler	4	0	10	10	1	25
Nashville Warbler	2	4	10	1	6	23
Yellow Palm Warbler	1	0	13	4	3	21
Oven-bird	3	1	4	4	7	19
Eastern Yellow Warbler	1	1	1	5	7	15
Blackburnian Warbler	2	2	4	1	1	10
Golden-winged Warbler	0	4	1	2	1	8
Bay-breasted Warbler	0	0	2	0	4	6
Worm-eating Warbler	0	2	1	1	0	4
Orange-crowned Warbler	0	0	2	0	2	4
Hooded Warbler	1	1	1	0	0	3
Cerulean Warbler	0	1	0	0	0	1
Northern Pine Warbler	0	0	0	0	1	1
Louisiana Water-Thrush	0	1	0	0	0	1
Mourning Warbler	0	0	0	0	1	1

TABLE 2. NATIVE BIRDS BREEDING IN CENTRAL PARK IN 1945.

Northern Flicker
Northern Downy Woodpecker
Eastern Wood Pewee (?)
Catbird
Eastern Robin
Wood Thrush
Red-Eyed Vireo (?)
Eastern Yellow Warbler
Purple Grackle
Eastern Cardinal (?)
Eastern Chipping Sparrow
Eastern Song Sparrow

TABLE 3. SOME SPECIES THAT HAVE DECREASED IN CENTRAL PARK WITHIN THE LAST TWENTY-FIVE YEARS.

Eastern Nighthawk
Bank Swallow
Northern Cliff Swallow
Eastern Crow
Northern Shrike

TABLE 4. SOME SPECIES THAT HAVE INCREASED IN CENTRAL PARK WITHIN THE LAST TWENTY-FIVE YEARS.

Greater Scaup Duck
American Merganser
Woodcock
Wilson's Snipe
Great Black-backed Gull
Laughing Gull
Eastern Mourning Dove
Eastern Hairy Woodpecker
Long-billed Marsh Wren
Philadelphia Vireo
Orange-crowned Warbler
Eastern Meadowlark
Eastern Vesper Sparrow

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THE GRACKLE *Photograph by Allan D. Cruickshank*

OTHER MUSEUM PUBLICATIONS ABOUT BIRDS

BIRDS AROUND NEW YORK CITY. By ALLAN D. CRUICKSHANK. 507 *pages, 36 illustrations. Cloth bound.* 1942. *Price* $1.75, *postage* 10¢. *Handbook No.* 13.

Indispensable to local bird students and of great interest to ornithologists at large. Although it is essentially a study of the birds of the New York City region, this book also includes northern New Jersey, Long Island, Rockland and Westchester counties.

BIRDS OF THE PACIFIC *in full color. Size:* 6⅞ *x* 8⅜ *inches. Price* 25¢, *postage* 3¢. *Portfolio No.* 2.

This is a portfolio of six plates reproduced in full color showing nine characteristic birds of the Pacific Islands.

BIRDS OF PARADISE. By ERNST MAYR. 14 *pages,* 22 *illustrations, three in full color. Paper bound.* 1945. *Price* 30¢, *postage* 3¢. *Science Guide No.* 127.

Here is a most interesting account of these extraordinary birds. The author gives an historical background and many little-known facts concerning their daily life.

THE HABITAT GROUPS OF NORTH AMERICAN BIRDS. By FRANK M. CHAPMAN. 64 *pages,* 36 *illustrations. Paper bound. 5th Edition revised and enlarged.* 1930. *Price* 25¢, *postage* 3¢. *Science Guide No.* 28.

These exhibition groups at the American Museum of Natural History are designed to illustrate not only the habits but also the haunts of the species shown.

WHITNEY MEMORIAL HALL OF PACIFIC BIRD LIFE. By ROBERT CUSHMAN MURPHY. 10 *pages,* 17 *illustrations. Paper bound,* 1939. *Price* 15¢, *postage* 3¢. *Science Guide No.* 101.

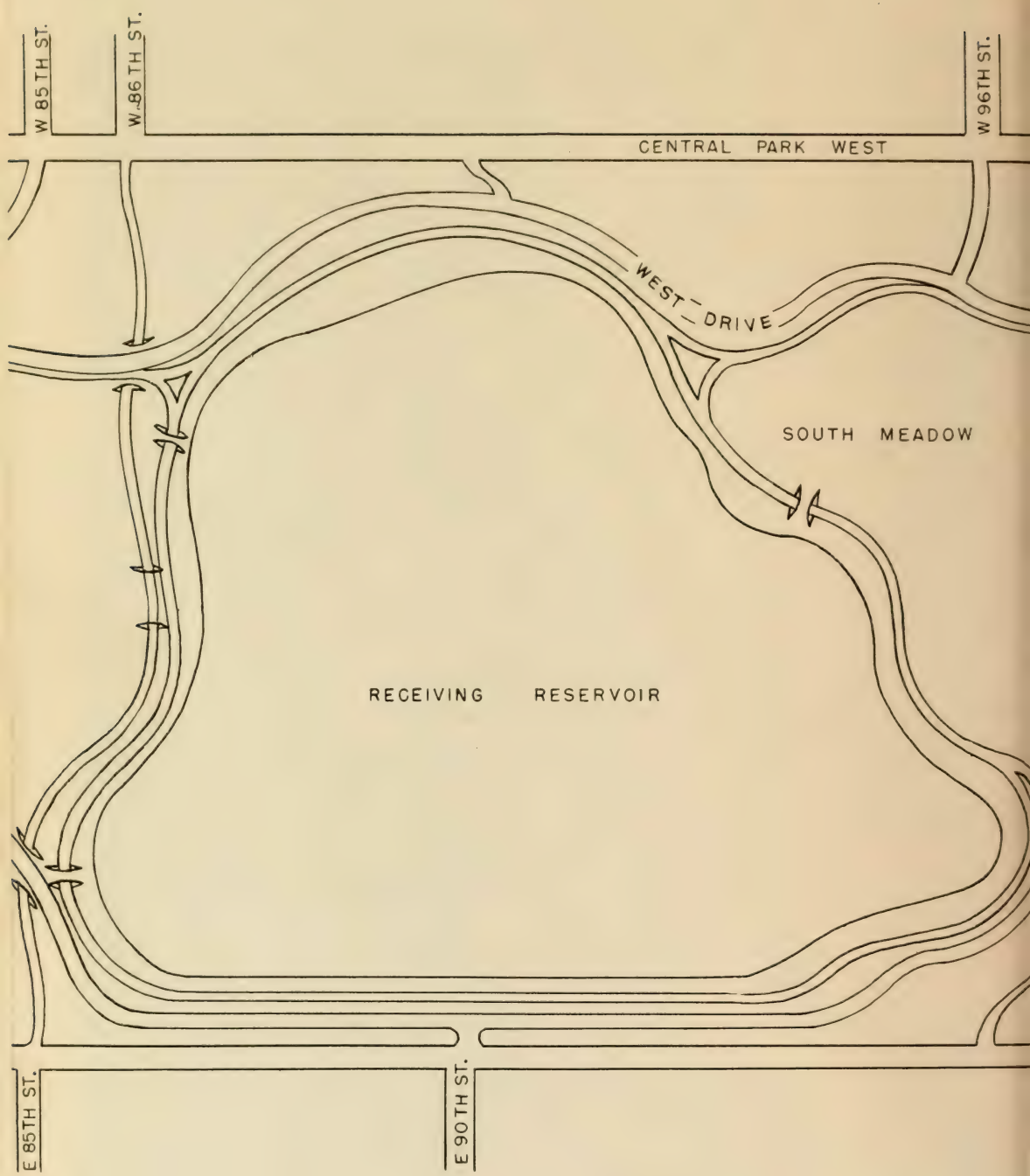
This is a general description of the Pacific bird exhibits in the new Whitney Wing of the American Museum of Natural History, which is the most commodious and best equipped ornithological headquarters in the world.

THE PREPARATION OF BIRDS FOR STUDY. By JAMES P. CHAPIN. 48 *pages,* 26 *illustrations. Paper bound.* 1946. *Price* 15¢, *postage* 3¢. *Science Guide No.* 38.

This booklet shows what tools are needed in mounting bird skins for study, how to skin a bird properly, how to fill out the skin, how to label and store skins for a collection.

THE URNER-EDWARDS FIELD CARD. NEW JERSEY AUDUBON SOCIETY. *Price* 2 *for* 5¢. *Chart J.*

These cards have a printed list of approximately 300 birds, a separate list of rarities, and space for weather data and field notes. An excellent aid in field work.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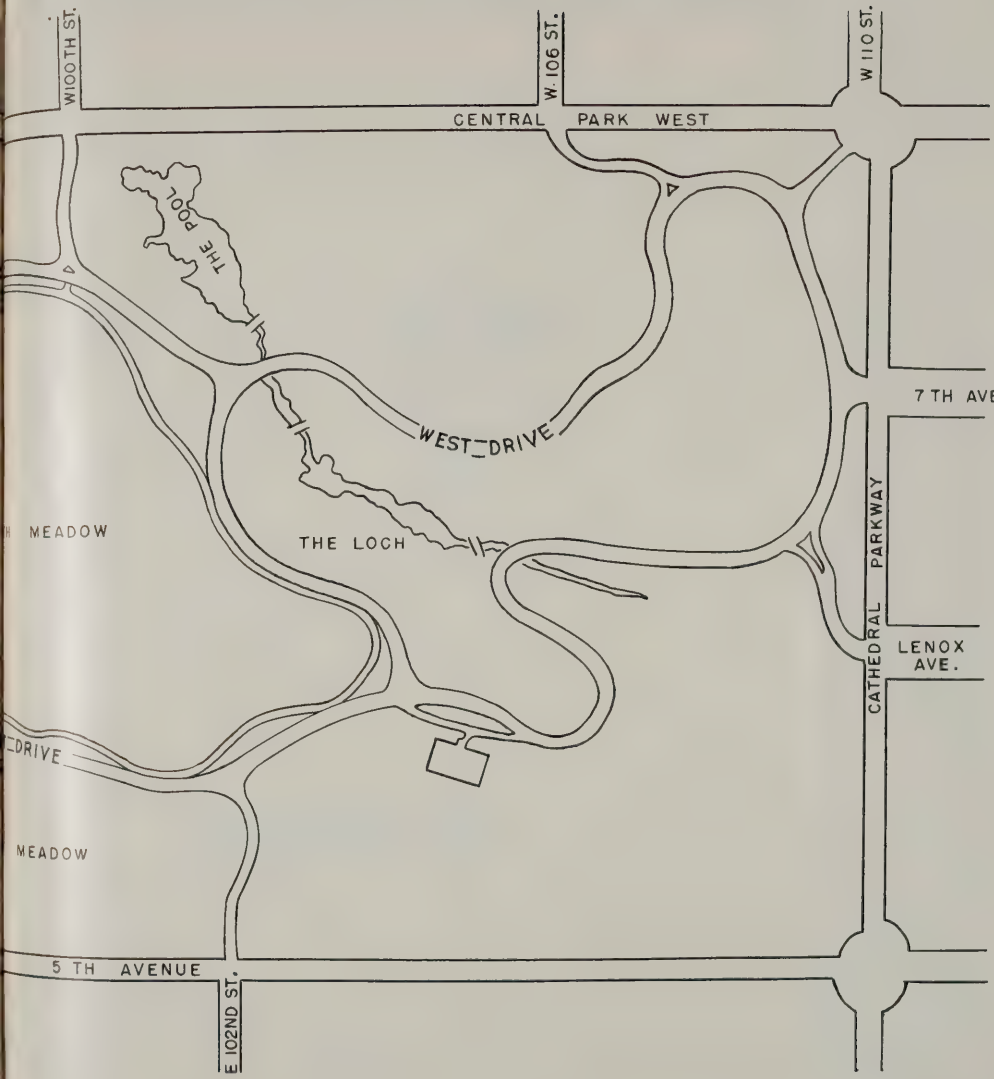
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DISTRIBUTIONAL LIST

OF THE

REPTILES AND AMPHIBIANS

OF THE

NEW YORK CITY REGION

By G. KINGSLEY NOBLE

Curator of Herpetology

THE AMERICAN MUSEUM OF NATURAL HISTORY

Guide Leaflet Series No. 69

NEW YORK

MARCH, 1929

THE REPTILES AND AMPHIBIANS OF THE NEW YORK CITY REGION

A DISTRIBUTIONAL LIST PREPARED FOR THE LINNÆAN SOCIETY OF NEW YORK

By G. Kingskey Noble

The reptilian and amphibian faunas found within seventy-five miles of New York City, in New Jersey, in the counties bordering the east shore of the Hudson, and on Long Island differ from one another in several particulars. The present list is prepared to call attention to these differences and to suggest gaps in our knowledge which we hope will be filled before many years by the many naturalists now in the local field.

The list is merely a preliminary statement of the general ranges of our local reptiles and amphibians. Exact locality records of practically all our species are greatly desired. It is only when they are brought together that a clear picture of the distribution of our local species can be obtained.

Information as to dates of appearance and disappearance of the species should be of interest to all observers in the local field. Observations on the habits of even the commoner species may prove of great scientific value. This is especially true of the breeding habits which are not well known even for some of our commonest form.

The number of reptiles and amphibians in the local region is not great, and their identifications should offer no difficulty. Convenient keys to the local species will be found in Pratt's "Manual of the Vertebrates of the United States" (P. Blakiston's Son & Co., Philadelphia). Other useful reference books would be: Dickerson's "Frog Book," Ditmars' "Reptile Book," and Blanchard's "A Key to the Snakes of the United States, Canada, and Lower California." There is, however, no book which gives the information most needed

by the New York field naturalist—namely, a full statement of the distribution of our local species.

The following list has been critically read by the Linnæan Society Committee on Local Herpetology and also by Messrs. Wm. T. Davis, G. P. Engelhardt, S. C. Bishop and W. De W. Miller. Further information in regard to the local reptilian and amphibian faunas may be obtained from the Chairman of this Committee or from the American Museum of Natural History.

The abbreviations refer to regions within 75 miles of New York City. L. I. = Long Island, N. J. = New Jersey, and N. Y. = southern New York, exclusive of Long Island.

1. Water Newt (aquatic form), Red Eft (terrestrial form)
   Triturus viridescens (Rafinesque)
   L. I., N. J., N. Y. Red Eft stage absent from L. I. and possibly from other sandy regions.
2. Jefferson's Salamander
   Ambystoma jeffersonianum (Green)
   L. I., N. J., N. Y. Rare. Locality records desired.
3. Spotted Salamander
   Ambystoma maculatum (Shaw)
   L. I., N. J., N. Y. Common.
4. Marbled Salamander
   Ambystoma opacum (Gravenhorst)
   L. I., N. J., N. Y. Not rare.
5. Tiger Salamander
   Ambystoma tigrinum (Green)
   L. I., N. J., N. Y. Rare except at certain L. I. localities.
6. Four-Toed Salamander
   Hemidactylium scutatum (Schlegel)
   L. I., N. J., N. Y. Locality records desired.
7. Red-Backed Salamander, Gray Salamander (two color phases)
   Plethodon cinereus (Green)
   L. I., N. J., N. Y. Common.

8. Slimy Salamander
Plethodon glutinosus (Green)
Absent from L. I.; common in N. J. and along the west shore of the Hudson, reported from Staten Island and from Westchester Co. but N. Y. records desired.

9. Purple Salamander
Gyrinophilus porphyriticus (Green)
Absent from L. I.; no definite locality records for our region but very probably found in N. J.

10. Muddy-Spring Salamander
Pseudotriton montanus (Baird)
Recorded from N. Y. Very rare.

11. Red Salamander
Pseudotriton ruber (Sonnini)
Absent from L. I.; only one N. Y. record except those from Staten Island and Rockland Co.; very common in N. J. Breeding and N. Y. records important.

12. Two-Lined Salamander
Eurycea bislineata (Green)
L. I., N. J., N. Y. Common.

13. Long Tailed Salamander
Eurycea longicauda (Green)
Only in N. J. Locality records desired as the species is known from N. Y. north of our area.

14. Dusky Salamander
Desmognathus fuscus fuscus (Rafinesque)
L. I., N. J., N. Y. Common.

15. Mountain Salamander
Desmognathus fuscus ochrophaeus (Cope)
Probably N. J. and N. Y. Additional records desired.

6. Spade-Foot Toad
Scaphiopus holbrookii (Harlan)
Common L. I.; rare elsewhere. Locality records desired.

17. American Toad
Bufo americanus Holbrook
Common N. J., N. Y., absent L. I. and Staten Island. What are its habitat preferences?

18. Fowler's Toad
Bufo fowleri Garman
L. I., N. J., N. Y. Common.

19. Cricket Frog
Acris gryllus (Le Conte)
L. I., N. J. Only one definite N. Y. record, other than Staten Island.

20. Common Swamp Tree Frog
Hyla (*Pseudacris*) *triseriata* (Wied)
Only N. J. and Staten Island. Not common.

21. Baird's Swamp Tree Frog
Hyla (*Pseudacris*) *feriarum* (Baird)
Often confused with the preceding species. Recorded from N. J., but definite records lacking.

22. Anderson Tree Frog
Hyla andersonii Baird
Pine barrens of N. J. Not rare.

23. Spring Peeper
Hyla crucifer Wied
L. I., N. J., N. Y. Common.

24. Gray Tree-Toad
Hyla versicolor (Le Conte)
L. I., N. J., N. Y. Common.

25. Bull Frog
Rana catesbeiana Shaw
L. I., N. J., N. Y. Common.

26. Pond Frog, Green Frog
Rana clamitans Latreille
L. I., N. J., N. Y. Common.

27. Pickerel-Frog
Rana palustris Le Conte
L. I., N. J., N. Y. Common. Usually a mountain frog (except on Long Island). Habitat records desired.

28. Leopard-Frog
Rana pipiens Schreber
L. I., N. J., N. Y. Common. Usually a salt marsh or coastal plain frog. Habitat records important.

29. Wood-Frog
Rana sylvatica Le Conte
L. I., N. J., N. Y. Common.

30. Sphagnum-Frog, Carpenter Frog
Rana virgatipes Cope
Pine barrens of N. J. Life history information important.

31. Six-Lined Swift
Cnemidophorus sexlineatus (Linné)
Reaching the extreme southern edge of our region in N. J.

32. Fence-Lizard
Sceloporus undulatus (Latreille)
Pine barrens of N. J.; N. Y. (only three locality records); northern records desired.

33. Blue-Tailed Skink
Eumeces fasciatus (Linné)
N. J., a few N. Y. records, others desired.

34. Worm-Snake
Carphophis amoena (Say)
L. I., N. J., N. Y. Rare. Records important.

35. Ring-Neck Snake
Diadophis punctatus edwardsii (Merrem)
L. I., N. J., N. Y. Habitat records desired.

36. Hog-Nosed Snake, Spreading Adder
Heterodon contortrix (Linné)
L. I., N. J., N. Y. Common. Habitat records important.

37. Smooth Green-Snake
Liopeltis vernalis (Harlan)
Common in N. J., rare in N. Y., and L. I. Locality records important.

38. Rough Green-Snake
Opheodrys aestivus (Linné)
Pine barrens of N. J., recorded, also from L. I. Locality records very important.

39. Black-Snake
Coluber constrictor (Linné)
L. I., N. J., N. Y. Common.

40. Corn-Snake
Elaphe guttata (Linné)
Pine barrens of N. J.

41. Pilot Black-Snake
Elaphe obsoleta (Say)
N. J., N. Y. Apparently absent from L. I. Usually a mountain species. Habitat and locality records desired.

42. Pine-Snake
Pituophis melanoleucus (Daudin)
Pine barrens of N. J.; one record from N. Y.

43. King-Snake
Lampropeltis getulus (Linné)
N. J.; possibly N. Y. Locality records much desired.

44. Milk-Snake
Lampropeltis triangulum (Lacépède)
L. I., N. J., N. Y. Common.

45. ?Kirtland's Snake
Natrix kirtlandii (Kennicott)
Possibly in the extreme southern edge of our region.

46. ?Queen-Snake
Natrix septemvittata (Say)
Possibly in the extreme southern edge of our region.

47. Water-Snake
Natrix sipedon (Linné)
L. I., N. J., N. Y. Common.

48. DeKay's Snake
Storeria dekayi (Holbrook)
L. I., N. J., N. Y. Common.

49. Red-Bellied Snake
Storeria occipito-maculata (Storer)
N. J., L. I. Definite N. Y. and L. I. records desired. Rare.

50. Gray Snake
Virginia valeriae Baird and Girard
Only N. J. Locality records desired.

51. Ribbon-Snake
Thamnophis sauritus (Linné)
L. I., N. J., N. Y. Common.

52. Garter Snake
Thamnophis sirtalis (Linné)
L. I., N. J., N. Y. Common.

53. Copperhead
Agkistrodon mokasen Beauvois
N. J., N. Y., absent L. I.

54. Timber Rattlesnake
Crotalus horridus Linné
N. J., N. Y., formerly present on L. I., but now exterminated.

55. Musk Turtle
Sternotherus odoratus (Latreille)
L. I., N. J., N. Y. Common in clear, highland ponds, rare on L. I.

56. Mud Turtle
Kinosternon subrubrum (Lacépéde)
L. I., N. J., N. Y. Common on the coastal plain. Highland records desired, also habitat notes.

57. Snapper
Chelydra serpentina (Linné)
L. I., N. J., N. Y. Common.

58. Spotted Turtle
Clemmys guttata (Schneider)
L. I., N. J., N. Y. Common.
The salt marsh specimens are distinctly rougher than the fresh water specimens.

59. Wood Turtle
Clemmys insculpta (Le Conte)
Common in N. J., rare in N. Y., probably absent from L. I., although there are several records. L. I. records very important.

60. Muhlenberg's Turtle
Clemmys muhlenbergii (Schoepff)
N. J., N. Y., absent on L. I. Locality records desired.

61. Blanding's Turtle
Emys blandingii (Holbrook)
Although this species has been recorded from L. I., it probably enters our region, only in the extreme north. Locality records desired.

62. Box Turtle
Terrapene carolina (Linné)
L. I., N. J., N. Y. Very common on L. I.; not rare elsewhere.

63. Salt Water Terrapin
Malaclemys centrata concentrica (Shaw)
Coasts of L. I., N. Y., and N. J.

64. Painted Turtle
Chrysemys picta (Schneider)
L. I., N. J., N. Y. Common.

65. Red-Bellied Turtle
Pseudemys rubriventris (Le Conte)
Coastal plain of N. J. Rare. Locality records desired.

66. Green Turtle
Chelonia mydas (Linné)
Accidental off our coast.

67. Hawks-Bills Turtle
Eretmochelys imbricata (Linné)
Accidental off our coast.

68. Loggerhead Turtle
Caretta caretta (Linné)
Regular visitant to our coast.

69. Kemp's Turtle
Caretta kempii (Garman)
Regular visitant to our coast.

70. Leather-Back Turtle
Dermochelys coriacea (Linné)
Rare along our coast.

THE DINOSAUR HALLS

BY

FREDERIC A. LUCAS

FIFTH EDITION

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HORNED DINOSAUR, TRICERATOPS

As reconstructed by Charles R. Knight. In the distance a pair of the contemporary Trachodonts.

THE DINOSAUR HALLS

By FREDERIC A. LUCAS

A DINOSAUR is a reptile, a member of a group long extinct, having no near living relatives, the crocodiles, though closer than any other existing forms, being but distantly connected. Neither are the great lizards from Komodo Island, which have attracted so much attention recently under the title of dragons, nearly related.

The name Dinosaur, terrible reptile, was bestowed on these animals because some of those first discovered were big, powerful, flesh-eating forms, but while we are apt to think of Dinosaurs as huge creatures yet there were many kinds of dinosaurs and they ranged in size from big Brontosaurus, with the bulk of four elephants, to little Compsognathus, no larger than a Plymouth Rock chicken.

The Dinosaurs lived mostly during the periods that geologists call Triassic, Jurassic and Cretaceous, periods of at least one hundred and forty million years. The race started in the Triassic period some 200,000,000 years ago and came to an end with the close of the Cretaceous about 60,000,000 years ago. In their day they were found over the greater part of the world, Europe, Asia, Africa, America, and Australia. It was a strange world in which they lived, a world peopled by reptiles, the Age of Reptiles, as the time is called. Besides the Dinosaurs there were crocodiles and turtles; flying reptiles, with a spread of wing greater than that of any living bird, and little pterodactyls about the size of a sparrow. In the sea during one period there were reptiles like porpoises and, later, they were succeeded by those something like great iguanas, but with paddles instead of feet, while with them were giant turtles far larger than any sea turtles of to-day. There were a few birds, some that flew and some that swam, but they differed from existing birds in having teeth.

There were no mammals in this ancient world, or at least only little ones something like small opossums.

There were no Elephants or Rhinos, no Buffalo or Deer, no Lions, Tigers, or Bears. Instead there were Dinosaurs, Dinosaurs everywhere, big lumbering creatures as big as many elephants, wading in the streams and lakes, feeding on water plants; smaller dinosaurs stalking by the water side or splashing into the water and swimming hastily away upon the approach of some big flesh-eating dinosaur looking for his dinner or supper, and little dinosaurs scurrying out of the way.

At the close of the Cretaceous great changes took place in the face of the earth and brought about changes in climate and in animal and plant life.

The reign of reptiles came to an end. The mighty dinosaurs and their little relatives passed away, and the mammals, hitherto few and small, began to increase and multiply until they became the possessors of the earth.

These changes did not take place suddenly but extended over many thousands of years. Gradually the mountains rose, the climate became drier and colder, the lakes and marshes dried up, and the reptiles adapted to a warm climate and easy life did not change with them, but fell by the wayside and perished, leaving their bones to testify to their former presence.

Many died on land, where, under the attacks of sun and rain, frost and snow, their bones went to pieces and crumbled into dust, leaving nothing to show of their former existence. But some sank to the bottom of lakes or streams, and some were swept into the ocean. In such places they were covered with mud or sand which as ages passed became beds of rock while the bones themselves changed to stone, became petrified, as it is popularly termed.

Millions of years later came man, puny and weak, from the dinosaur view-point, but possessed of a brain and hand that soon made him the ruler of the earth. As he gradually increased in intelligence he became interested in learning about the races that had preceded him in time and, finding the bones of dinosaurs, began to collect and study them and to gather them into places he called museums. So it came to pass that after millions of years these former lords of creation were brought from their sepulchers and placed in the Halls of Dinosaurs to arouse the wonder of visitors.

While Dinosaur bones have been found in various parts of the earth, yet the places where they are really abundant and accessible are comparatively few in number, the best hunting grounds so far discovered being in Utah, Wyoming, Montana, and Alberta. In some localities, like the Connecticut Valley, we know dinosaurs were common because they have left their foot prints on what was once the shore of an arm of the sea, but very few of these bones have been found. They were probably dissolved or swept out to sea and buried beyond our reach.

THE DINOSAURS

Many books and articles, mostly scientific, have been written about Dinosaurs. This leaflet deals with but a few of these creatures, selected from those displayed in the Dinosaur Halls of the Museum

On the right and left of the entrance of the Cretaceous Hall are two good-sized, lightly but powerfully built, flesh-eating dinosaurs known to science as **Gorgosaurus**. As shown by their build and hollow bones, they were doubtless swift and fierce and preyed upon their smaller, feebler fellows, as Lions and Tigers to-day prey upon Zebra, Antelope, and Deer. The big, strong hind legs, with a stride of ten to fifteen feet, carried them swiftly over the ground, and their great claws were fitted for holding and tearing their prey The diminutive fore legs, also armed with sharp claws, helped to tear up their food.

Near them are examples of a rather small dinosaur whose legs and general build suggest an Ostrich with a long tail, and called on account of this resemblance **Struthiomimus**. This animal far from being a "terrible reptile" was toothless, and his fingers were long and slender, not at all fitted for tearing anything. It has been thought that they were adapted for carrying eggs which were stolen from the burying places of other dinosaurs, the long, slender legs enabling the thief to run away from any pursuers.

Towering above the others, his head eighteen feet from the ground, is **Tyrannosaurus,** the well-named King of Reptiles, whose terrible jaws and tremendous claws placed all contemporaries at his mercy.

Triceratops, a lumbering, huge-headed creature, was a plant eater, probably of coarse vegetation. His jaws ended in a great horny beak for clipping off branches and rushes, and his back teeth were adapted for champing them. These back teeth were arranged in many rows and were all the time pushed upward by new teeth forming below, so that as fast as teeth wore out they were replaced, a point in which Triceratops might well be envied. The fore legs, bowed outward at the elbows, enabled the animal to reach the ground with ease and the big "frill," suggesting a fireman's helmet, was not alone for protection, but served as a counterweight to the head and jaws, so the skull almost balanced on the condyle, or ball joint by which it joined the neck.

Triceratops had numerous relatives who rang all possible changes on their frills and horns, some of the frills being mere margins of bone, some with plain edges, some decorated with star-like points like the head of a giant horned toad. Some had, as the name implies, three

horns, others, like Monoclonius, only one. Triceratops suggests a Rhinoceros, but has no relationship whatever with that animal—it is a case of appearance only, what is called analogy, not homology.

In the center of the hall is a group of Dinosaurs which seem to have been very abundant in their day, **Trachodon** and his relatives.

A bit of the skin impression of a Duck-billed Dinosaur, about natural size

Corythosaurus, Saurolophus, and others. Among these is one of the rare prizes that sometimes fall to the lot of the collector, a specimen in which the impression of a large part of the skin has been preserved, so that we are certain as to the covering of the animal. The reptile is supposed to have died on land, been baked in the hot sun and then swept into the bed of a stream by a freshet and buried in the sand. What the antelopes are to Africa, these creatures were to North America, the characteristic animals of the country. They rang the changes in the shape of their heads, which varied in an extraordinary fashion. They were water-dwelling animals with powerful, compressed tails and webbed feet. This last we know from the "mummied" specimen. Like the carnivorous dinosaurs, they were three-toed animals and walked erect. That they did *not* drag their tails is shown by the fact that there is no groove or furrow between the footprints. The tail acted as a balance or counterpoise to the body, and the many slender bones along the sides of the vertebræ show that there were many strong muscles that carried the tail off the ground without any exertion on the part of the animal.

Many of the Dinosaurs which at a much earlier date (Triassic) dwelt in what is now the Connecticut Valley and left their footprints

in the sand of time also walked on their hind legs, with their tails clear, and as there was no mark of a tail it is not surprising that the footprints were thought to be those of gigantic birds and so described and named.

Two very extraordinary armored dinosaurs are represented by only parts of their skeletons. **Ankylosaurus** which Dr. Lull has called "the most ponderous animated citadel the world has ever seen" had its head and body protected by thick plates of bone, while the tail instead of tapering to a point ends in a great ball of bone.

We can imagine that when attacked Ankylosaurus flattened himself along the ground and wagged his tail. As the carnivorous Dino-

Allosaurus in the role of a scavenger feeding upon part of Brontosaurus

saurs had no big hind toe, such as is found in birds of prey, while they could tear, they could only grasp downward and the big claws would find it a difficult matter to get hold of an armour-clad back, and if a leg or tail came in contact with the big knobbed tail of Ankylosaurus it would assuredly be smashed.

Near Ankylosaurus is the fore part of **Palaeoscincus** whose sides bristled with huge, bony spines and whose back was protected by bony plates so that he too was well able to defend himself.

Dominating the Jurassic Hall is **Brontosaurus,** the Thunder Reptile, big-bodied, small-headed, with massive limbs whose joints, in life covered with gristle, indicate that he was largely a water dweller, where the great weight of his body, about 15 tons, would be supported.

The small head and feeble teeth tell that Brontosaurus was a vegetable feeder, and looking at the big body one feels that it must have kept the head busy to supply it with needed nourishment.

Near-by Brontosaurus is **Allosaurus,** apparently turned into a fossil while munching on the tail of a defunct relative of that big beast. Looking closely one sees that the tops of the Brontosaurus vertebræ are scored with grooves where some millions of years ago it was feasted upon by some flesh-eating contemporary. It is not necessary to suppose that Allosaurus killed the huge creature on which it is feeding. Just as there were active, vicious carnivores so there may have been those who played the role of Hyænas and fed upon anything they found dead. Of course it is not at all certain that this particular Allosaurus feasted upon this very Brontosaur, but their skeletons were found within a few miles of one another, so that it is quite possible that they were associated in life as in death.

American Museum party at Bone-Cabin Quarry, 1899. Seated, left to right Walter Granger, Professor H. F. Osborn, Dr. W. D. Matthew; standing, F. Schnieder, Prof. R. S. Lull, Albert Thomson, Peter Kaisen. This was a famous locality for Dinosaurs.

Perhaps some readers may feel as did the good old lady who said she did wonder how they knew the names of these old animals when they found them, or if not may wonder why they have such long names.

It was long ago discovered that not only did so-called common names mean nothing, but that there would not be enough for all the animals that would be discovered. So a Swedish naturalist, Linnæus, devised the plan of giving every kind of animal two names, the first a general, or generic name, that should be borne by him and his relatives, the other a special, or specific name, that should apply to that particular kind or species. These names, usually taken from the Greek or Latin, as a rule allude to some apparent character of the animal to which they are applied, as shown by the generic names of Greek origin which follow:

Allosaurus, leaping reptile. From its supposed active habits in springing upon its prey.

Ankylosaurus, fused reptile. In allusion to the manner in which the bony plates are fused, or ankylosed, with the bones of the skeleton.

Brontosaurus, thunder reptile. So heavy that the earth trembled beneath its tread.

Corythosaurus, helmeted reptile. From the shape of the skull which suggests that of a crested helmet.

Deinodon, terrible teeth.

Gorgosaurus, fierce reptile.

Lambeosaurus, Lambe's reptile. Named in honor of Dr. Lambe of the Geological Survey of Canada.

Monoclonius, single battler. In allusion to the single horn on the nose.

Ornitholestes, bird robber. Alluding to the theory that his activity enabled him to catch birds.

Struthiomimus, ostrich mimic. From the resemblance of its skeleton to that of an ostrich.

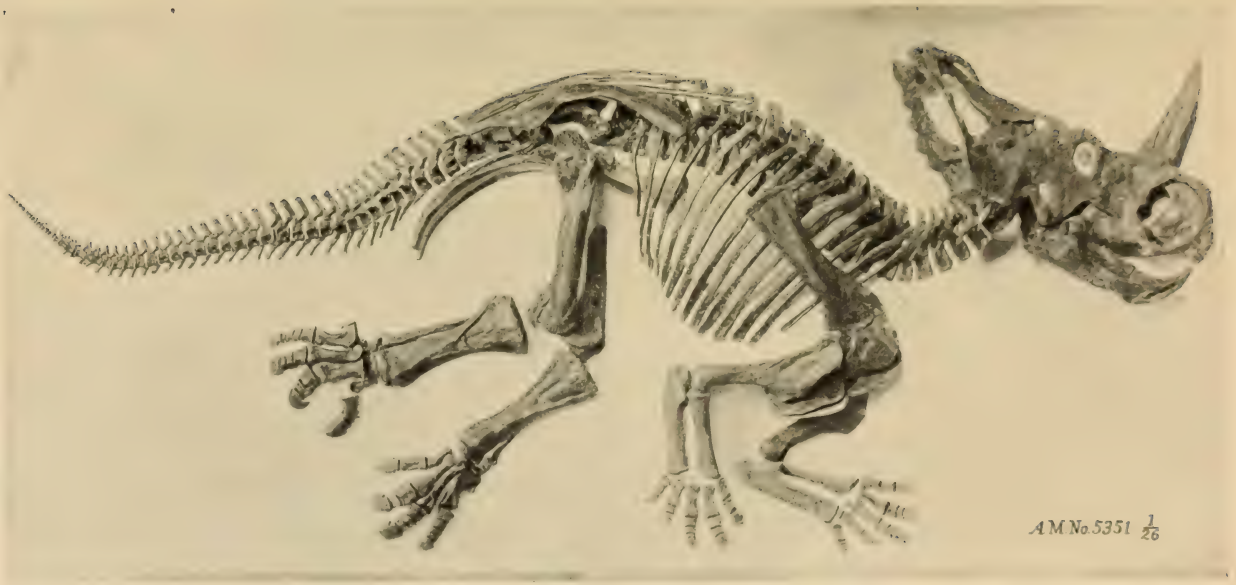
Trachodon, rough teeth. In allusion to the ridges on the side of the teeth.

Triceratops, three-horned face.

Tyrannosaurus, tyrant reptile.

HORNED DINOSAUR, TRICERATOPS

A Cretaceous Dinosaur from Montana. Length 24 feet, height 7 feet 9 inches, weight when alive about nine or ten tons, twice the weight of an average Indian Elephant.



MONOCLONIUS

A relative of Triceratops from the Cretaceous of Alberta.

DUCK-BILLED DINOSAURS, TRACHODON

From the Cretaceous of Montana and South Dakota. 33 feet long, standing 17 feet 6 inches high. These were among the most abundant of the dinosaurs, apparently as common as deer are to-day.

"MUMMIED" DINOSAUR, TRACHODON

From the Cretaceous rocks of Wyoming. By a fortunate combination of circumstances a great part of the skin impression of this animal has been preserved for millions of years. See cut in text.

DUCK-BILLED DINOSAUR, TRACHODON

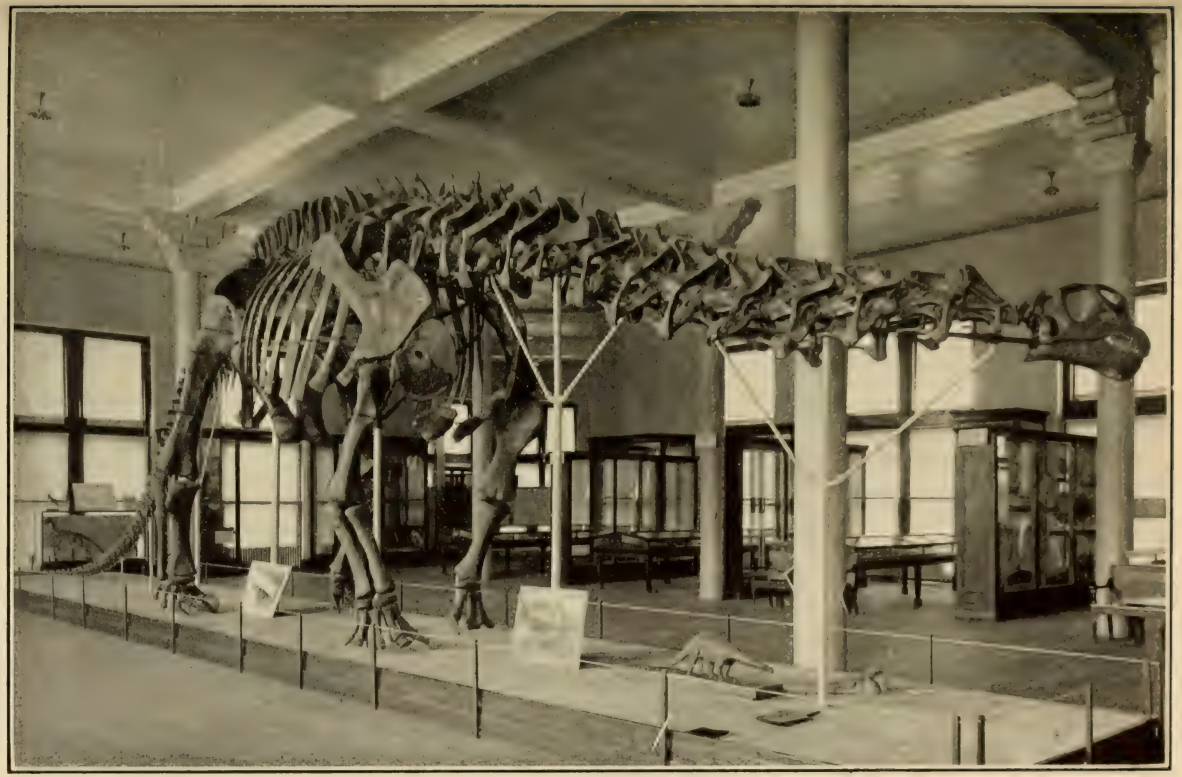
From the Cretaceous of Wyoming, as reconstructed by Charles R. Knight. In walking the tail was carried clear of the ground.

THE KING OF REPTILES. TYRANNOSAURUS REX

Forty-seven feet long, 18 feet 6 inches high as he now stands. From Montana. Lived in the Cretaceous Period.

SKULL OF TYRANNOSAURUS

This skull is four feet long. The largest of the double-edged teeth are six inches long. As in other reptiles the teeth when broken, or worn out, were replaced by others. New teeth are seen coming into place in the back of the upper jaw.

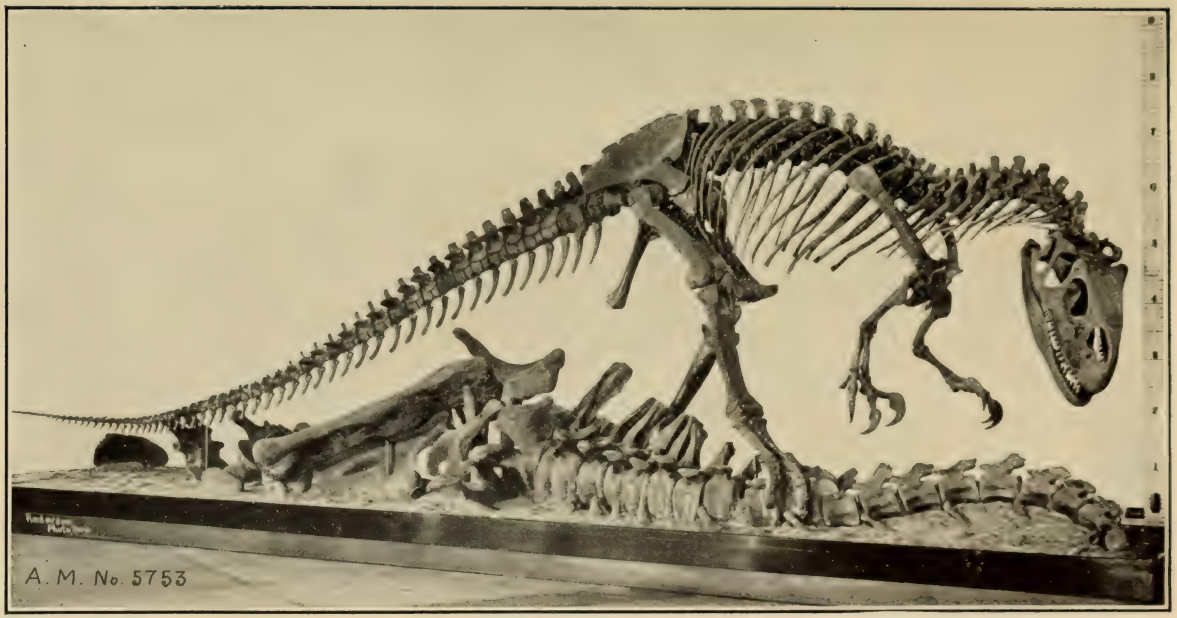


BRONTOSAURUS, THE THUNDER REPTILE

From the Jurassic of Wyoming. Sixty-six feet long, 15 feet high, weighed in life about 15 tons. A big Asiatic Elephant weighs 5 tons. This was the first large dinosaur to be placed on exhibition. The preparation and mounting of the skeleton occupied the better part of six years.

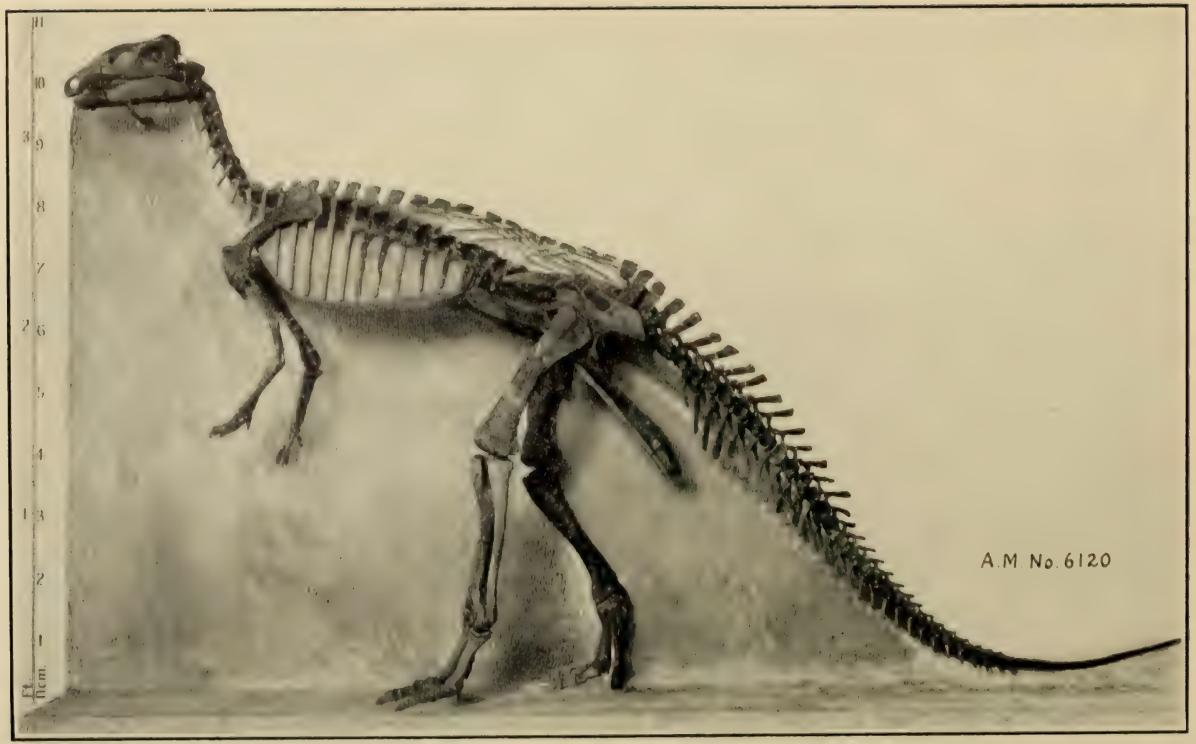
BRONTOSAURUS, THE THUNDER REPTILE

Reconstruction by Charles R. Knight. Shown as dwelling in the water in which these great creatures are supposed to have passed most of their time, feeding upon water plants.



ALLOSAURUS

A Jurassic, flesh-eating dinosaur, possibly a scavenger, though well provided with teeth and sharp claws.

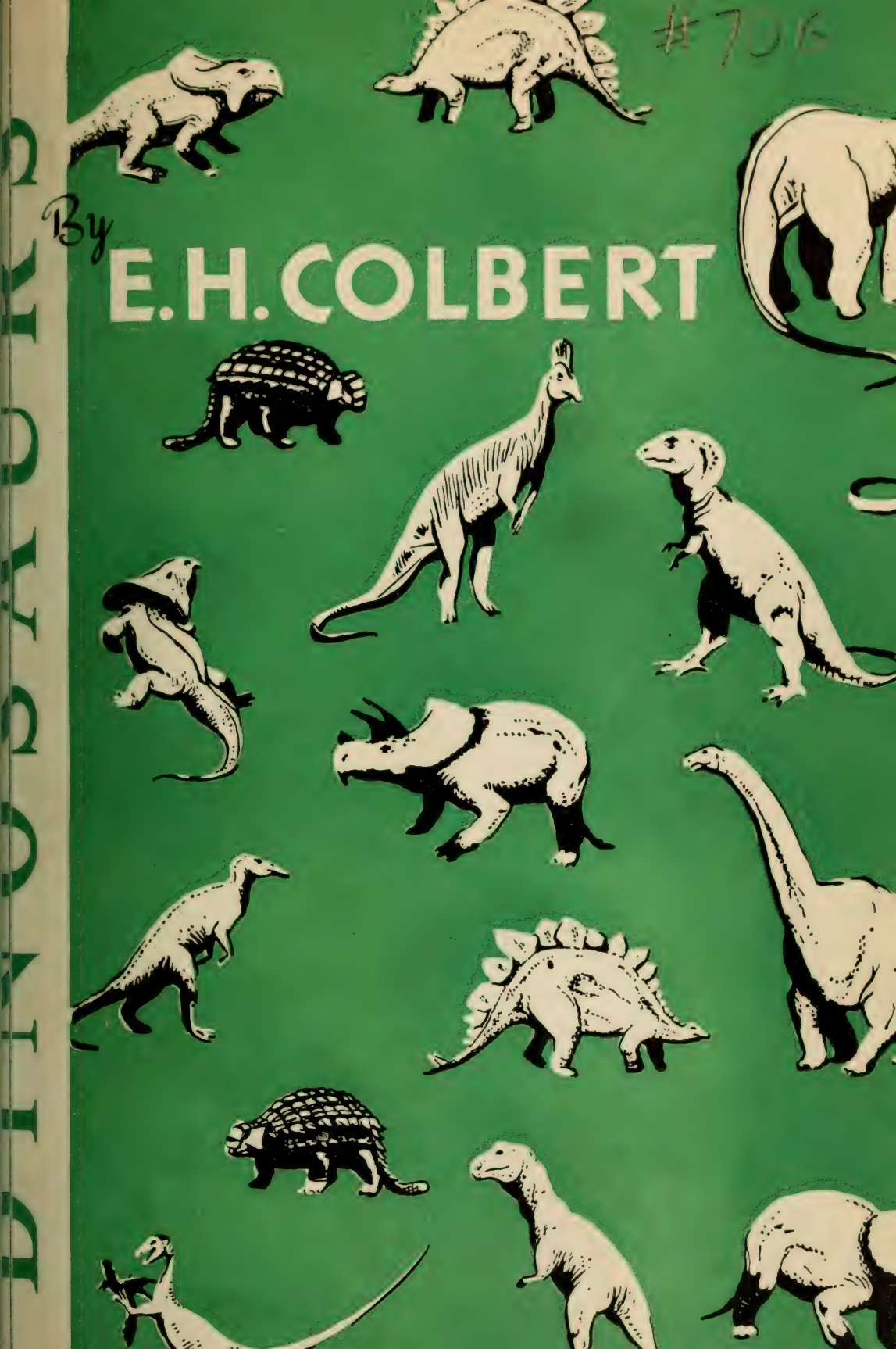


CAMPTOSAURUS

A small Jurassic Dinosaur, a plant-eater standing about four feet high.

#706

By E. H. COLBERT



DINOSAURS

By EDWIN H. COLBERT
Curator of Fossil Reptiles, Amphibians, and Fishes

Science Guide No. 70

NEW YORK CITY
THE AMERICAN MUSEUM OF NATURAL HISTORY
1947

Occasionally, the soft parts of animals are fossilized as well as the bones. Here a fossilized mummy of *Trachodon,* a Cretaceous duck-bill dinosaur, is shown. The original skin has been replaced by minerals, but the pattern and texture of the skin are preserved.

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DINOSAURS

By EDWIN H. COLBERT

What is a Dinosaur?

Many millions of years ago the world was inhabited by various reptiles which we now call dinosaurs. These dinosaurs were abundant and widely spread; they dominated the land over all of the great continental areas, and they frequently spread to offshore islands. They reigned supreme through a vast expanse of geologic time.

Now they are extinct, and we know them only by their fossilized remains. We must reconstruct them and we must interpret their past history from the evidence of the fossils in the rocks and from the rocks themselves, for no man, even the most remote of our ancestors, ever saw a living dinosaur. These reptiles had been long extinct before the first men appeared on earth. Yet the fossilized bones and the rocks in which the bones are found have given us, through assiduous and careful study, a comprehensive picture of the dinosaurs, so that today we know quite a lot about these ancient reptiles. Indeed, these animals have become so well known that even the word "dinosaur" is a common noun in our vocabulary, and almost every literate person in the Western World has some idea as to what the word *dinosaur* means.

But for a great many people, the matter ends there. The dinosaurs to a large percentage of the public were gigantic animals that lived long ago—nothing more. In fact, the word dinosaur has come to be more or less synonymous in many minds with giantism and with great age. But the word means much more than this.

What is a dinosaur? What are the inherent characters of the fossils that we call dinosaurs; what determines their classification as such? Is it size? Is it age?

The dinosaurs were reptiles, cold blooded animals related to the crocodiles, lizards, and snakes, and they lived during the Mesozoic Era of earth history. Not all dinosaurs were large, as is commonly thought. Many of them were small or of medium size. Taken together all of them show a tremendous variety of adaptations for different modes of life in different environments. They first appeared in the early part of Mesozoic times, about 200 million years ago, and the last of the dinosaurs became extinct at the end of the Mesozoic Era, about 60 to 70 million years ago.

The ancestors of the dinosaurs were bipedal reptiles—they walked on strong hind legs and the front legs served as grasping organs—so all of the dinosaurs are characterized by the large size of the hind legs as compared with the front legs. Even those dinosaurs that walked on all four feet show a great disparity in size between the fore and hind limbs, a proof that the four-footed pose in such animals was secondary, derived from a primitive bipedal pose. In all dinosaurs the bones of the ankle and of the wrist are much reduced in number. In all dinosaurs the skull is characterized by one or more openings in front of the eye and by two large openings for accomodation of the bulging jaw muscles behind the eye. There is also an opening or fenestra in the lower jaw. In all dinosaurs the teeth in the skull are confined to the margins of the jaw; there are no teeth on the palate as in many other reptiles. These are some of the more important characters common to all the various reptiles that we call dinosaurs.

There are two orders of dinosaurs, known as the Saurischia and Ornithischia.

These names are derived from the structure of the pelvis in the two orders of reptiles. In the Saurischia (sawr-ISS-kee-ya) the three bones on either side of the pelvis are arranged more or less according to the typical reptilian pattern, making a triradiate or three-pronged structure around the hip-joint. In the Ornithischia (orn-ith-ISS-kee-ya) one bone, the pubis, has rotated to a position parallel with the ischium, so that the pelvis resembles in a general way the pelvis of birds.

There are other differences, but the differences in pelvic structure, outlined above, are basic. The Saurischia were in part meat-eating dinosaurs, in part plant-eating forms, whereas the Ornithischia were all herbivorous or plant eaters. In the Saurischia the teeth are arranged around the front and sides of the jaws or are limited to the front, whereas in the Ornithischia there are never any teeth in the front of the jaws, either above or below. The Saurischia appeared early in Mesozoic times, in the Triassic Period, and lived throughout the extent of this long geologic Era: the Ornithischia did not arise until the middle of Mesozoic times, the Jurassic Period, and were confined largely to the Cretaceous period, the last portion of the Era.

Primary Classification of the Dinosaurs

ORDER SAURISCHIA

Saurischian pelvis, with the pubis directed anteriorly. Meat-eating and plant-eating dinosaurs with teeth in front and sides of jaws. Lived during the Triassic, Jurassic and Cretaceous periods.

Suborder Theropoda

The theropods. Carnivorous or meat-eating dinosaurs. Bipedal, walked on the hind legs with the front legs used for grasping. Active, upland forms. Small to large. Triassic through Cretaceous.

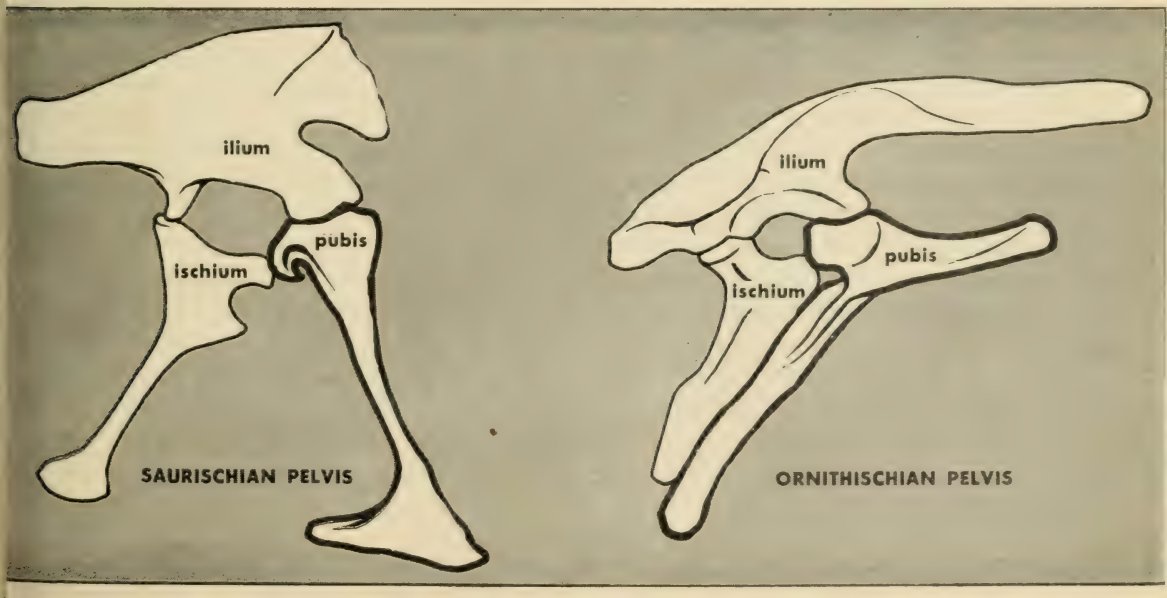
Suborder Sauropoda

The sauropods. Herbivorous or plant-eating dinosaurs. Quadrupedal; walked on all four legs. Giant, swamp-dwelling dinosaurs. Neck and tail very long, skull small with teeth limited to front of jaws. Upper Triassic through Cretaceous.

ORDER ORNITHISCHIA

Ornithischian pelvis with the pubis rotated parallel to the ischium. Plant-eating dinosaurs with the teeth limited to the sides of the jaws. Lived during the Jurassic and Cretaceous periods.

All dinosaurs are divided into two groups according to the plan of the hip bones. On the left is the typical reptilian arrangement seen in the Saurischia. On the right is that of the Ornithischia, which resembled the pelvis in birds.



Suborder Ornithopoda

The ornithopods or duck-billed dinosaurs. Partially bipedal and partially quadrupedal; walked on hind legs or on all fours. Lived along river and lake shores and spent much time in the water. Small to large. Jurassic to Cretaceous.

Suborder Stegosauria

The stegosaurs or plated dinosaurs. Quadrupedal, upland forms. Large, but with a small head. Plates on the back with spikes on the tail. Mainly Jurassic.

Suborder Ankylosauria

The ankylosaurs or armored dinosaurs. Quadrupedal, upland forms. Large, heavily armored with scutes and spikes. Cretaceous.

Suborder Ceratopsia

The ceratopsians or horned dinosaurs. Quadrupedal, upland forms. Small to large. Skull very large, and generally with one, three or more horns. Upper Cretaceous.

With the outline as presented above, and as pictured in the accompanying family tree of the dinosaurs, one can view these long-extinct beasts with a fair amount of understanding. In the following pages the several suborders will be discussed, and some of the details of the structure, habits and distribution of the reptiles belonging to these dinosaurian groups will be elucidated.

Geologic Time

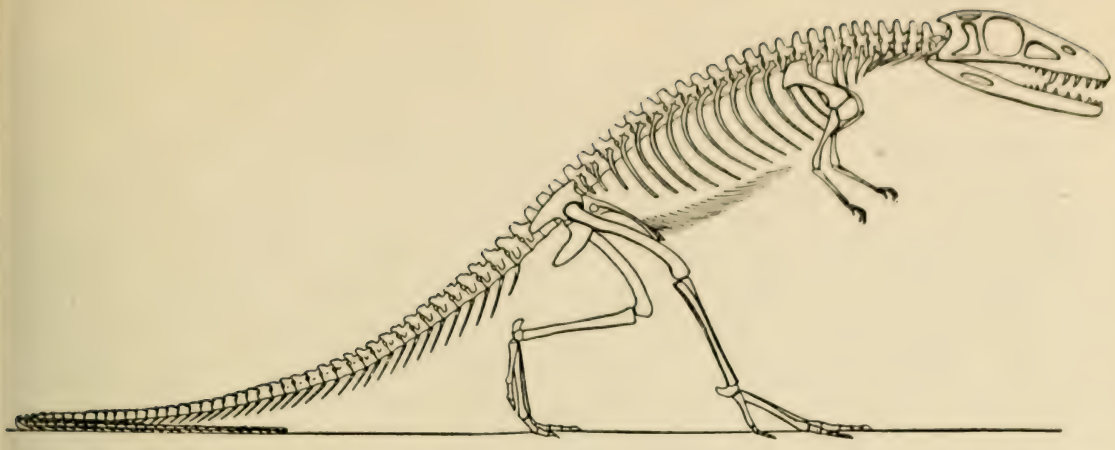
It has been said above that the dinosaurs lived through the Mesozoic Era of earth history, that they first appeared about 200 million years ago and that they became extinct some 60 to 70 million years ago. Perhaps at this place it would be well to take up the important subject of geologic time, for to understand the dinosaurs it is necessary among other things, to have some appreciation of the long Era through which they lived. Time, to us as humans, is a matter of minutes, days, and years, and human experience for most of us is a matter of something less than a century. The historian thinks in terms of centuries, and he is usually regarded as taking a "long view" of things. But the student of the earth thinks not in terms of centuries or even of millenia, but rather in terms of millions of years, and to think in such large terms as these, to take such an extremely "long view" of life and the earth, requires a certain amount of mental readjustment.

The earth is generally estimated by modern scholars to be about two billion years old. This is not a mere guess; it is based largely upon a study of the disintegration of radioactive minerals.

Of this two-billion year span of earth history, about three-fourths is without any fossil record; in other words, the first fossils are found in rocks that go back about 500 million years in age. We know that there must have been life on the earth before the period at which fossils first appear, but it is evident that the organisms living earlier than about 500 million years ago were so primitive and soft-bodied that their remains were not preserved as fossils. The oldest fossils preserved in the rocks of the earth already represent comparatively complex organisms, well along the evolutionary road and belonging to various well-defined groups.

Earth history as recorded by the fossil record has been divided into three great eras, each of which has been subdivided into several periods. The chart of geologic time shows the three eras, the periods in each and the approximate duration of the several periods. It shows also the dominant life of each era.

It will be seen that the Paleozoic Era, which began about 550 million years ago, was in its earlier periods an age of water-living animals, of invertebrates and fishes. Only in the upper parts of the Paleozoic did the back-boned animals come out of



From this sort of pattern, all of the varied dinosaurs developed: the skeleton of *Saltoposuchus,* a Triassic thecodont reptile only about four feet long.

Modified from von Huene

the water, to begin life on land. These were the early amphibians, related to our modern salamanders and frogs. From the amphibians the reptiles arose during late Paleozoic times.

The Paleozoic Era ended about 200 million years ago and the Mesozoic Era—the age of dinosaurs—began. This era of earth history, comprised of three periods, the Triassic, Jurassic and Cretaceous, and continuing through a span of about 140 million years, was the time of dinosaurian dominance. The dinosaurs ruled the land as thoroughly as do the mammals of the present time. Their reign was complete and it was long.

With the end of the Mesozoic Era and the transition from Mesozoic to Cenozoic times, some 60 million years ago, the dinosaurs became extinct. From then on to the present mammals were supreme on the land, and during the past few thousand years one mammal, Man, has ruled the surface of the earth. Because the dinosaurs have been extinct we are inclined to think of them as "failures" in the history of evolution. But were they failures? For 140 million years they were the dominant land animals throughout all of the continental areas. Man as such has been on the earth considerably less than a million years. Who is Man, then, to say that the dinosaurs were not successful?

Geologic and Geographic Distribution of the Dinosaurs

It has already been said that the dinosaurs were numerous and widely distributed during the Mesozoic Era of earth history. The distribution of these reptiles in time and space can best be shown by the accompanying chart and map. It is to be remembered that the record here presented is based upon the known fossil evidence at the present time; naturally future explorations and discoveries will fill out the record, particularly in certain parts of Asia, Africa and South America, for which there is as yet but very little geological information.

CRETACEOUS

JURASSIC

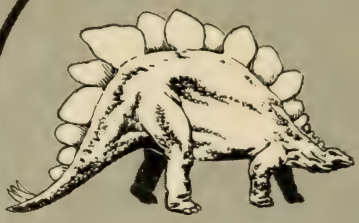
TRIASSIC

CERATOPSIANS (Horned Dinosaurs)
Herbivorous, four-footed dinosaurs with horns on the head

THEROPODS (Carnivorous Dinosaurs)
Primarily flesh-eaters that walked on hind legs and used front limbs for grasping

ORNITHOPODS
(Duck-billed Dinosaurs)
Herbivorous, both two-legged and four-legged forms, generally living in the water along river and lake shores

ANKYLOSAURS (Armored Dinosaurs)
Herbivorous, four-footed, armored animals



STEGOSAURS
(Plated Dinosaurs)
Herbivorous, four-footed armored types

SAUROPODS (Giant Dinosaurs)
Herbivorous dinosaurs that generally walked on all fours; the giants of the dinosaur world

ORNITHISCHIAN DINOSAURS

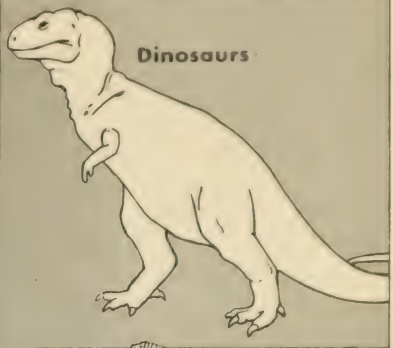
SAURISCHIAN DINOSAURS

A SIMPLIFIED FAMILY TREE OF THE DINOSAURS

The two-footed ancestors of all the dinosaurs, the Thecodontia, gave rise to two main orders of dinosaurs and six suborders, as shown above

THECODONTIA
Ancestors of all dinosaurs

Drawings by John C. Germann

Time Scale	ERAS	Duration of periods	PERIODS	DOMINANT ANIMAL LIFE
0			Recent	
10			Pleistocene	Man
20	CENOZOIC 60 million years duration	60	Pliocene Miocene Oligocene Eocene Paleocene	Mammals
60				
70				
80				
90		60	Cretaceous	 Dinosaurs
100	MESOZOIC 140 million years duration	35	Jurassic	
150		45	Triassic	
200		25	Permian	Primitive reptiles
		20	Pennsylvanian	Amphibians
250		30	Mississippian	
300		65	Devonian	Fishes
350	PALEOZOIC 350 million years duration	35	Silurian	
400		75	Ordovician	Invertebrates
450		90	Cambrian	
500				
	PROTEROZOIC ARCHAEOZOIC		1500 MILLION YEARS DURATION	BEGINNINGS OF LIFE

Only during the last 500 million years have plants and animals produced hard parts capable of being fossilized. Here is a simplified chart of that quarter of the earth's history. *Drawings by John C. Germann*

Ancestors of the Dinosaurs

The early thecodont reptiles, the ancestors of the dinosaurs, were relatively small animals, generally no more than four to six feet in length. They were essentially bipedal—that is, they walked on strong hind legs in a semi-erect pose and the front legs, which were reduced in size, were not used for walking but rather as grasping organs. Thus the body was pivoted at the hip joint, and since it was not carried in an erect position as in Man (also a bipedal animal) there was a long tail to serve as a counterbalance to the body and the head. With the hip joint serving as a fulcrum and the long tail acting as a nice counterbalance, the body could be lowered for feeding or raised for walking or running.

The three bones on each side comprising the hip or pelvis were arranged in a three-pronged fashion; one, the ilium, on top; one the pubis, pointing down and forward; one, the ischium, pointing down and backward. The hind legs were rather long and strong, and the hind feet were very much like the feet of birds. The forelimbs, as already mentioned, were much smaller than the hind limbs and the forefeet were armed with claws. The neck was relatively short and the skull was rather large.

The skull in the thecodonts was lightly built but strong, deep and narrow. The eye was large. In front of the eye was a large opening on either side, presumably to reduce the amount of bone and thus lighten the skull, while behind the eye were two large openings on either side that allowed for the bulging of the jaw muscles. The lower jaw was long and hinged at the very back of the skull, and both the upper and lower jaws were armed with sharp, pointed teeth.

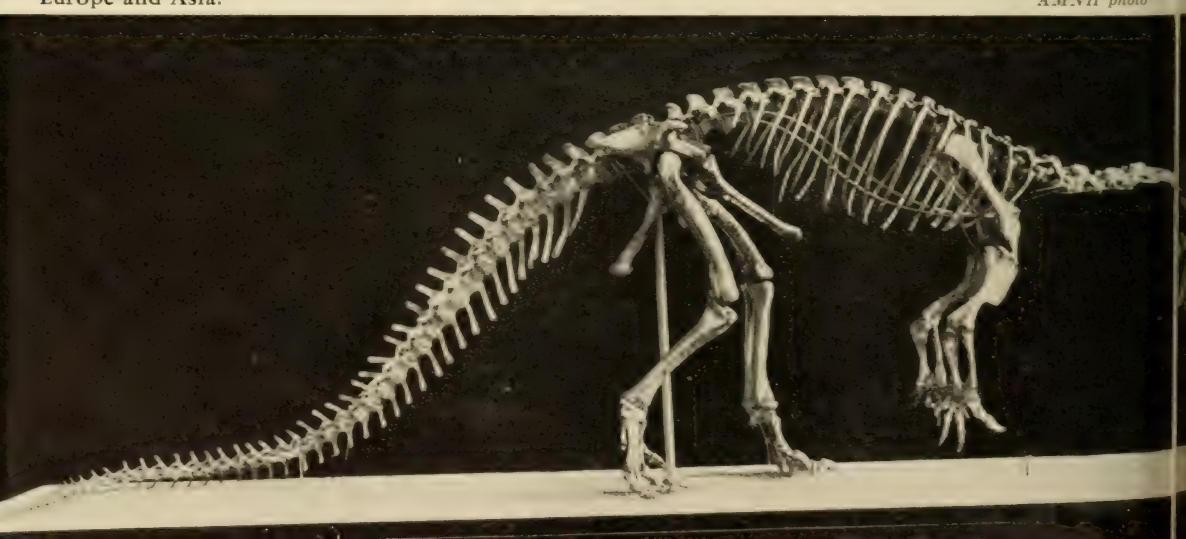
The first Triassic dinosaurs retained without very great changes this thecodont structural pattern. They were small animals, and except for certain refinements in the pelvis, feet and skull, the description given above for the thecodont ancestor of the dinosaurs will apply to the earliest dinosaurs, the primitive theropods.

Triassic Dinosaurs

Triassic theropod dinosaurs are not common. Skeletons have been found in rocks of Upper Triassic age in Central Europe and New Mexico, and we know from the great numbers of tracks preserved in the Connecticut Valley that these ancestral dinosaurs must have been very abundant in Upper Triassic times in eastern North America.

Some tracks of these Triassic theropod dinosaurs are on display in the corridor between the two dinosaur halls, on the left side of the Pterosaur mural (1). These are three-toed tracks, so bird-like in general appearance that when the tracks were first found in the Connecticut Valley, about one

The beginnings of sauropod history are well exemplified by the Triassic dinosaur, *Plateosaurus,* found in Europe and Asia. *AMNH photo*



hundred years ago, it was generally supposed that they had been made by some sort of extinct bird. We now know that the first birds did not appear until late Jurassic times, many millions of years after these dinosaur tracks were made.

On the right side of the Pterosaur mural are the tracks of a gigantic theropod dinosaur of Cretaceous age. (2).

One Triassic dinosaur skeleton is to be seen in the Jurassic Hall. This is the skeleton of *Plateosaurus* (3), an ancestral sauropod dinosaur from the Upper Triassic of Württemberg, Germany. Although this dinosaur was trending toward the adaptations that became so characteristic of the giant sauropod dinosaurs, *Plateosaurus* still retained many of the characters of the primitive Triassic dinosaurs. Thus, this was a bipedal animal with a rather lightly constructed skeleton.

Jurassic Dinosaurs

The Upper Jurassic dinosaur, *Ornitholestes* (4), though much later in age than the primitive ancestral theropods, was in many respects a persistent primitive type. It was small, as were the ancestral theropods, and lightly built. It was thoroughly bipedal, with very bird-like hind limbs and feet and strong, grasping, three-fingered hands. The small skull is delicate yet strongly braced, and the jaws are armed with sharp, pointed teeth, an indication that *Ornitholestes* preyed upon other small reptiles and any other animals that it could catch. In the restoration it is represented as catching *Archaeopteryx,* the first known bird.

Contemporaneous with *Ornitholestes* was the giant theropod, *Allosaurus* (5). Here we see the line of adaptation characteristic of most of the theropod dinosaurs of Upper Jurassic and Cretaceous age. These were the giant meat-eaters, the predators that lived upon other giant dinosaurs.

Allosaurus, like all of the theropods, retained the primitive bipedal pose, with the body pivoted at the hip. The mounted skeleton, posed to represent *Allosaurus* as feeding on the carcass of a *Brontosaurus,* demonstrates very well how the long tail served to counterbalance the body. *Allosaurus* retained also the relatively small forelimbs typical of the ancestral theropods, and the hands consist of three fingers armed with large claws. In this dinosaur, as in all of the later gigantic meat-eaters, the head became very large. Increase in the size of the skull and jaws gave a greater gape or bite, and this together with the large, blade-like teeth, increased the efficiency of *Allosaurus* as a best of prey. It will be seen that even though the skull is very large, it is lightly constructed, with the openings in front of and behind the eyes greatly enlarged, to cut down the dead weight of bone. There is nothing ponderous about this skull, in spite of its size.

The Jurassic Hall is dominated by the huge skeleton of *Brontosaurus* (6). This dinosaur is typical of the suborder of saurischian dinosaurs known as the sauropods—a group of animals that lived during the Upper Jurassic and Cretaceous times, the giants among the dinosaurs. The skeleton of *Brontosaurus* is some 67 feet in length and in height it measures 15 feet at the hips, the highest region of the back. When alive, this animal probably weighed about 35 tons, which would make it about 7 times as massive as a large African elephant. Yet *Brontosaurus* was not the largest of the sauropods; *Brachiosaurus,* a very massive form known from fossils found in this country and in East Africa measured some 80 feet in length and had a probable live weight of more than 40 tons!

It should be mentioned here that huge as they were, the sauropod dinosaurs do not represent the extremes in size among animals. Our modern whales, such as the sperm whale, and the right whale (lengths up to 60 feet, weights up to 60 tons) or the huge blue whale (length up to 100 feet, weight up to 130 tons) are the largest animals that have ever lived. However, these giant whales are buoyed up by the water which is their perpetual home, and it is evident that they have gone beyond the

AMNH photo

Ornitholestes was no mo
than five or six feet
length, including the ta

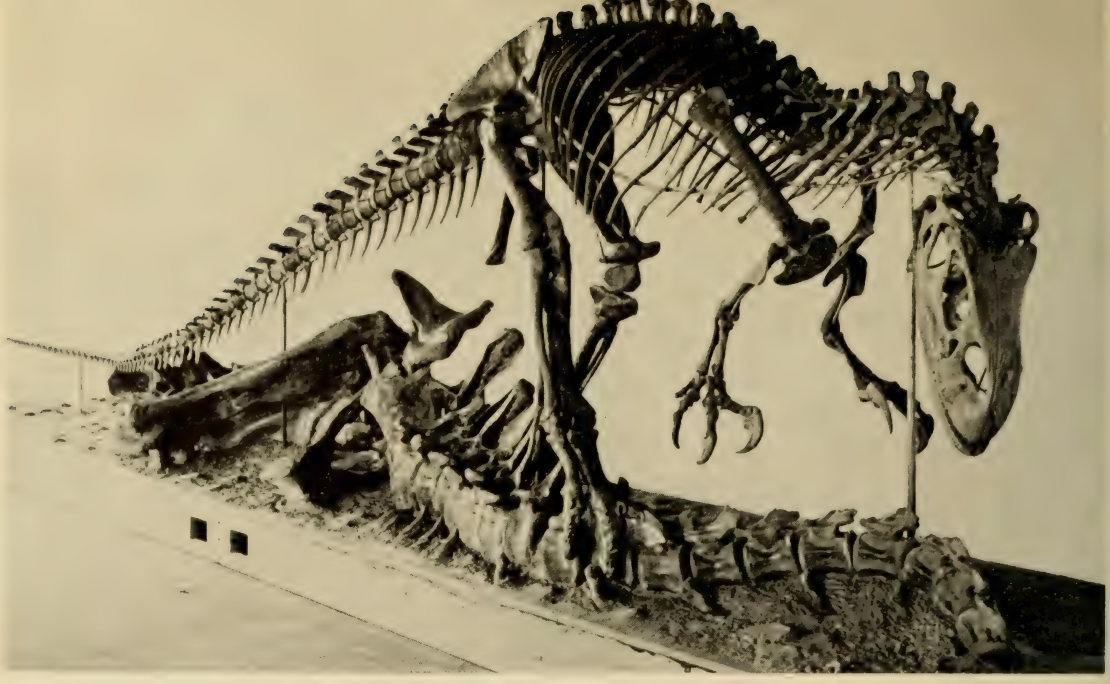
In the restoration belo
this small theropod din
saur is represented in t
act of catching the fi
known bird, *Archae*
pteryx.

Restoration by Charles R. Knight

Important localities where dinosaurs have been discovered.

The Fossil Record of the Dinosaurs throughout the World

	South America	North America	Northern Asia	Southern Asia, India	Australian Region	Europe	Africa
Theropods	Cretaceous	Triassic—Cretaceous	Cretaceous	Triassic—Cretaceous	Cretaceous	Triassic—Cretaceous	Triassic—Cretaceous
Sauropods	Cretaceous	Jurassic—Cretaceous	Cretaceous	Cretaceous	Jurassic	Jurassic—Cretaceous	Jurassic
Ornithopods		Jurassic—Cretaceous	Cretaceous			Jurassic—Cretaceous	Jurassic—Cretaceous
Stegosaurs		Jurassic				Jurassic	Jurassic
Ankylosaurs	Cretaceous	Cretaceous	Cretaceous			Cretaceous	Cretaceous
Ceratopsians		Cretaceous	Cretaceous				



Skeleton of *Allosaurus,* a carnivorous dinosaur of Jurassic times, shown feeding on a *Brontosaurus* backbone. *AMNH photo*

mechanical limits possible for a land-living animal. The sauropod dinosaurs probably do represent about the maximum size that can be attained by land animals, where bone, muscles and ligaments must support the body against the constant downward pull of gravity.

Naturally the ancestral bipedal pose was not possible in an animal the size of *Brontosaurus,* so this dinosaur, and the other sauropods as well, had secondarily reverted to the four-footed pose that is characteristic of most land-living vertebrates. *In Brontosaurus* the neck and tail are very long; the head is relatively quite small. The limbs are heavy and post-like, to form supporting pillars for the heavy body, and the feet are broad and compact. On the front foot there is a single clawed toe—the rest of the toes lacked terminal claws and were enclosed within the pad of the foot, much like the toes of elephants—while on the hind foot there are three claws. On the base of the *Brontosaurus* mount are casts of brontosaur footprints, discovered a number of years ago in Texas. These show imprints of the single claw of the front foot and of the three claws of the hind foot.

Restoration of *Allosaurus.* *Restoration by Charles R. Knight*

Brontosaurus, shown restored to the left, was a marsh-living dinosaur of Jurassic age.

Below—Skeleton of *Brontosaurus,* 67 feet in length, 15 feet in height at the hips

The vertebrae in *Brontosaurus,* though large and strong, are lightly constructed, thereby cutting down on the dead weight of bone in the spinal column. Large hollows are present in these vertebrae, and bony trusses or buttresses give strength to the vertebrae and afford muscle attachments for the powerful back muscles. In the skull, the peg-like teeth are limited to the front of the jaws and are relatively few in number. The nostrils are located on the top of the skull, a sure indication that *Brontosaurus* was a water-loving dinosaur.

It is evident that *Brontosaurus* was a semi-aquatic animal, frequenting marshes and rivers, living quite inoffensively on the plants that grew in the shallow water or along the shore. This dinosaur found its protection in its great size, and more especially by retreat to the swamp or river where it could wade or swim in deep water with only the top of the head protruding above the surface.

There were various other sauropod dinosaurs contemporaneous with or subsequent to *Brontosaurus,* and these are

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Skeleton of *Stegosaurus,* an armored dinosaur of the Jurassic period. *AMNH photo*

Skeleton of *Camptosaurus,* one of the first of the ornithischian dinosaurs. *AMNH photo*

represented in the exhibit hall by parts of skeletons of *Diplodocus* (7) and *Barosaurus* (8), and by skulls of *Diplodocus* and *Morosaurus* (9), and by a model skeleton and restoration of *Camarasaurus* (10). *Diplodocus* was a very long, slender sauropod, longer than *Brontosaurus* but not so massive; *Barosaurus* was a large dinosaur with an unusually heavy neck; *Camarasaurus* was another large sauropod, similar in many respects to *Brontosaurus.* A rather complete skeleton of *Barosaurus* is preserved in the Museum but is not exhibited at the present time because of lack of suitable display space.

Plateosaurus (3), mentioned above, gives us some idea of the transition that took place in the evolution of the huge sauropods from theropod ancestors. *Plateosaurus* may be considered as a primitive sauropod, for it shows many trends toward the typical sauropod characters, such as an elongating neck and the enlarging of the fore limbs. Yet in the partially bipedal pose, the structure of the backbone and the structure of the hind feet this dinosaur shows its theropod heritage. It was truly a connecting link.

Certain ornithischian dinosaurs were contemporaneous with the Upper Jurassic saurischian dinosaurs, the theropods and sauropods already described. *Camptosaurus* (11) was the most primitive and central of the ornithischians, and it represents essentially the stem form, descended from early theropod-like ancestors, from which the later great array of ornithischians evolved. It is a small, bipedal dinosaur and in these respects it shows its primitive heritage. But certain characters stamp it as a true ornithischian, especially the structure of the pelvis and of the skull. In the skull, as in all of the ornithischians, the teeth are limited to the sides of the jaws. *Camptosaurus* was a plant-eating dinosaur, and in this respect it set the pattern for all members of the order Ornithischia, for these were exclusively herbivorous.

Several Lower Cretaceous camptosaurs (12, 13) are exhibited at the present time in the east end of the Jurassic Hall.

Stegosaurus (14) was an ornithischian typical of the suborder Stegosauria, the plated dinosaurs. This dinosaur also was of Upper Jurassic age. Like the saurischian *Brontosaurus, Stegosaurus* shows a complete

Restoration of *Camptosaurus,* a five to eight-foot plant-eating dinosaur. *Restoration by John C. Germann*

secondary reversion to a four-footed pose, but the great disparity in size between the fore and hind limbs clearly indicates the ultimate derivation of this dinosaur from primitive bipedal ancestors. Indeed, there is little doubt but that *Stegosaurus* was descended from a camptosaur-like dinosaur. Certainly the skull in *Stegosaurus* is nothing more than an elongated *Camptosaur* skull, and it is remarkable because of its small size as compared with the rest of the animal.

In *Stegosaurus* the legs are strong and the feet broad. The backbone is strongly arched, because of the great length of the hind limbs as compared with the fore limbs. The pelvis is characteristically ornithischian in structure. Of course the distinctive feature that immediately attracts the eye is the double row of huge plates running along the top of the backbone and the four large spikes on the end of the tail. The spikes quite obviously were for protection, for when the tail was lashed back and forth these made a dangerous weapon to be used against any adversary. But the purpose of the great plates on top of the back is not so clear.

From the skeletons found with the plates more or less in place it is obvious that these were embedded by their broad bases in the skin and muscle tissue of the back. A skeleton now preserved in the United States National Museum in Washington shows these plates as alternating, and for this reason, together with the fact that no two plates are quite alike, some authorities have thought that the alternating arrangement of the plates is correct. Good arguments can be advanced, however, for arranging the plates opposite each other.

In this dinosaur there was an enlargement of the spinal cord in the hip region that was some twenty times as large as the brain, but *Stegosaurus* did not have a "second brain" as has often been said; rather the sacral enlargement of the spinal cord was for motor control of the large hind limbs and the tail.

Ornitholestes, Allosaurus, Brontosaurus,

Skeleton of *Tyrannosaurus,* the largest carnivorous land animal that ever lived. *AMNH photo*

Camptosaurus and *Stegosaurus* are all found in western North America in the Morrison formation of Upper Jurassic age. These are a true association of contemporaneous dinosaurs, and they show us the various adaptions among the dinosaurs that constituted a *fauna* of that far off time. A similar fauna of the same age lived in East Africa; an indication of how widely spread and dominant the dinosaurs were during Mesozoic times.

In the southeast corner of the Jurassic Hall is the skeleton of *Nodosaurus* (15) an armored ornithischian belonging to the suborder Ankylosauria. This dinosaur, of Cretaceous age, is characterized by the massive armor of integrated bony scutes that covered the body and the top of the skull. Like all of the other ornithischians it was an inoffensive plant-eater, in spite of its formidable appearance.

Restoration of *Tyrannosaurus,* attacking the horned dinosaur, *Triceratops.* *Restoration by Charles R. Knight*

Cretaceous Dinosaurs

Dominating the south end of the Cretaceous Hall is the skeleton of the giant carnivorous theropod, *Tyrannosaurus* (16). *Tyrannosaurus,* of uppermost Cretaceous age, was the extreme end form in the evolution of the giant meat-eaters, exemplified in the Jurassic period by *Allosaurus. Tyrannosaurus* is even larger than *Allosaurus*; the skull is actually and relatively much larger, and the front legs are still more reduced. The skeleton of *Tyrannosaurus* as mounted is 47 feet in length and the top of the head is 18½ feet above the base of the mount. This animal probably weighed about six or eight tons when alive.

The skull on the skeleton is a plaster cast of the original skull, which is exhibited separately where it can be conveniently seen (17). A closeup view gives the observer some appreciation of the huge size of the skull, the great blade-like teeth, and the strength of the jaws in *Tyrannosaurus.*

Two skeletons of *Gorgosaurus,* Upper Cretaceous carnivores closely related to *Tyrannosaurus,* are exhibited on either side of the south door to the Cretaceous Hall (18, 19). In addition, skulls of the carnivorous theropods, *Dromaeosaurus, Albertosaurus* and *Gorgosaurus* (20) are on display on the north side of the hall.

Another Upper Cretaceous theropod was *Struthiomimus,* of which two specimens are on display (21, 22). This dinosaur followed a line of evolution quite apart from its carnivorous relatives. It retained the primitive bipedal pose, but the neck was elongated and the skull reduced in size. Moreover all of the teeth were lost, so that the front of the skull has the form of an ostrich-like beak. Evidently *Struthiomimus* was an ostrich-like dinosaur (this does not imply any real relationship to the ostrich) that could run rapidly, and that fed omnivorously upon insects, small reptiles, fruits and other plant food.

The two skeletons of *Trachodon* or *Hadrosaurus* (23) form the central group at the northern end of the Cretaceous Hall. *Trachodon* was one of numerous varied forms that constitute the so-called duck-billed dinosaurs or hadrosaurs, specialized ornithopods of Upper Cretaceous age. All of these dinosaurs were characterized by the elongation of and flattening on the front of the skull and jaws; hence the name "duck-bill." It is evident that these dinosaurs, which were water-living animals, groveled in the mud along the edges of streams and lakes or in marshes, to feed upon aquatic plants and perhaps small animals as well. As in other ornithischian dinosaurs, teeth are absent from the front

of the jaws, but on either side of the upper and lower jaws there is a complex battery of interlocking teeth which in life formed an ever growing and efficient grinding mill. In fact there were about 500 teeth on either side in each of the upper and lower jaws, or about 2000 teeth in all in the skull and jaws of *Trachodon!* Some trachodont jaws (24) show very clearly the implantation of the teeth in this dinosaur.

The skeleton of *Trachodon* shows that this dinosaur was partially bipedal and partially quadrupedal: it could stand more or less erect or it could walk on all fours. The feet are compact and the toes terminate, in both fore and hind feet, in separate, flattened hoofs. The tail is very long, narrow and deep, and it served not merely as a balancing structure, but also as a powerful swimming organ, with which the animal could propel itself through the water in much the same fashion that a crocodile or alligator swims, by a side-to-side movement of the tail.

All evidence points to the fact that the duck-billed dinosaurs were quite at home in the water. Because of the habits of these dinosaurs and the conditions under which they were fossilized, they are frequently found as fossilized mummies, in which not only the bones are replaced with minerals and preserved as fossils, but also the skin is fossilized. This gives us accurate information, except for color, about the outward appearance of these dinosaurs. A very fine fossil mummy of *Trachodon* (25) is on display next to the two mounted skeletons. This fossil mummy shows the pattern of the skin, which was tough and leathery, and it shows also webs of skin between the toes, as would be expected in a swimming animal.

Another piece of fossilized dinosaur skin (26) is to be seen toward the south end of the Cretaceous Hall. In addition, large portions of fossilized skin are present in some of the other hadrosaur skeletons on display.

Restoration by Erwin S. C

AMNH photo

ow, on the opposite
e, is a restoration of
birdlike theropod,
thiomimus. To the
it is the skeleton.
jaws developed as
at horny beak that
ht have been useful
eating fruits, other
n things, insects,
small reptiles.

The duck-bills evolved along various lines of adaptation, marked particularly by differences in the structure of the skull. A display of skulls (27) demonstrates evolution in the hadrosaurs during the Upper Cretaceous. From a generalized from such as *Trachodon* evolution in the skull was mainly a matter of enlargement and complication of the bones which housed the nasal passage. These bones began to be enlarged in *Kritosaurus* and *Prosaurolophus.* Then in *Hypacrosaurus* they grew back over the skull to form a high crest within which the nasal passage, going back from the nostrils, formed an S-shaped loop. An even more highly specialized condition evolved in *Lambeosaurus,* while in *Parasaurolophus* the bones housing the nasal passage reached such an extreme of development that they formed a huge crest that swept far back beyond the back of the skull. The purpose of these extreme specializations in the later hadrosaurs is not clearly understood. It has been thought that perhaps the elongated nasal passage which occupied the enlarged crest was an air storage chamber, or an air "lock" that would be useful to an aquatic animal.

Two skeletons of *Corythosaurus* (28, 29) are exhibited at the north end and on the east wall of the Cretaceous Hall. Also on the east wall is a skeleton of a very large duck-bill, *Saurolophus* (30) and two skeletons of the relatively small *Procheneosaurus* (31, 32).

Another group of ornithopod dinosaurs which might well be called the "bone-headed" dinosaurs are exemplified by *Troödon* and *Pachycephalosaurus* (33). In

To the right are skeletons of *Trachodon,* a duck-billed dinosaur of late Cretaceous times.

On the opposite page, *Trachodon* is restored in a painting showing the aquatic habits o the duck-bills which spent much of their time either in or near the water.

AMNH photo

these dinosaurs there was an inordinate thickening of the skull roof so that a heavy, solid covering of bone was built up above the brain.

The Ankylosauria or armored dinosaurs of the upper Cretaceous are represented by a partial skeleton of *Palaeoscincus* (34) and by skulls of *Ankylosaurus* (35). These dinosaurs, shown in the chart on page 8, were moderately large, completely quadrupedal or four-footed, and had the body and head covered by a heavy armor of bony scutes. There were frequently large spikes along the side of the body. It would seem that these dinosaurs could crouch down on the ground and take protection in their heavy covering, as nowadays do the turtle or the armadillo. In *Ankylosaurus* there was a large club or knot on the end of the tail, which when swung with force must have been very effective in keeping enemies at a safe distance.

The last of the dinosaurs were the ceratopsians or the horned dinosaurs, represented by a considerable display in the Cretaceous Hall. These ornithischian dinosaurs first appeared in the Upper Cretaceous period, and went through the many ramifications of their evolutionary history during a comparatively short lapse of geologic time.

It is probable that the ceratopsians had their origins in some small ornithischians

exemplified by the Mongolian form, *Psittacosaurus* (36), exibited with the fossils from Mongolia, in the hall just to the south of the Cretaceous Hall. This is a small ornithischian, rather generalized in the skeleton with a retention of the primitive bipedal pose, but with the skull enlarged and deepened. The front of the skull is very parrot-like in its general form—hence the name.

The first undoubted ceratopsian, however, was *Protoceratops,* known from a fine series of materials discovered some years ago in Outer Mongolia. These are on display with the Mongolian fossils. *Protoceratops* (37, 38) was a rather small dinosaur, some five or six feet in length. In spite of its small size, this dinosaur had almost completely reverted from the ancestral bipedal pose to a four-footed mode of locomotion. The fore and hind feet are strong and the toes terminate in separate hoofs, as is common among the ornithischian dinosaurs. The structure of the skull in *Protoceratops* is remarkable, for it has become greatly enlarged. In front the skull and jaw forms a deep, strong beak, as in *Psittacosaurus* while at the back the posterior bones of the skull roof have grown back and enlarged to form a bony crest or frill extending over the neck and shoulder region. This frill was for the attachment of strong muscles that moved the head. It need only be mentioned that *Protoceratops* and all of the other ceratopsian dinosaurs, like all of the ornithischians, subsisted upon plant food.

Protoceratops is known not only from adult skeletons but also from an extraordinarily fine series of skulls showing growth stages from the newly hatched reptile to the fully adult individual. (39). This series shows how during growth from baby to adult the frill became increasingly larger.

Protoceratops is justly famous by reason of the fact that unhatched fossil eggs were found in association with the skulls and skeletons of this animal. It had been supposed for many years that dinosaurs were egg-laying reptiles, but until the discovery of the eggs with *Protoceratops* proof for this deduction was lacking. Several nests were discovered, and a number of single eggs; in all more than seventy. Some of the nests and individual eggs as well, are on display in association with the *Protoceratops* skeletons (40, 41, 42). The eggs of this dinosaur are very similar in shape to the eggs of modern lizards; that is, they are

Restoration by Charles R. Knight

elongated, with one end considerably bigger in diameter than the other. The surface is pebbly in texture, and it would appear that the egg shell was leathery, as in modern reptile eggs. Eggs were deposited in the sand for hatching, in concentric circles, in a fashion similar to the deposition of eggs by some of the modern marine turtles. One nest of eggs (40) shows in whole or in part three concentric circles of eggs. In this nest the eggs are shown upside down (this was how they were found) and a restoration of the nest showing the eggs in their normal position is included in the *Protoceratops* exhibit (38).

Leptoceratops (43) was a primitive North American ceratopsian closely related to the Mongolian *Protoceratops.* It will be noticed that in both *Protoceratops* and *Leptoceratops,* horns are only incipient at the most; it was later, among the larger ceratopsians, that the horns so characteristic of these dinosaurs reached the full stage of development.

One of the most characteristic of the giant Upper Cretaceous ceratopsians was *Triceratops* (44), a skeleton of which is mounted at the south end of the Cretaceous Hall. Here we see a culmination of the trends that were beginning in *Protoceratops.* The skeleton of *Triceratops* is 20 feet long and stands about seven feet high at the hips. The skull is enormous, totaling a length of 6½ feet, which is approximately one third the total length of the animal. Of course about half of the skull length is taken up by the frill, which in *Tricratops* is solid, not fenestrated or open as in the more primitive ceratopsians. This frill formed an expanded attachment for huge muscles that controlled the movements of the head, and it must have been of some use as protection too, covering the vital neck region. However, *Triceratops* was protected most effectively by three long horns one above each eye and one on the nose. These horns, borne on a huge skull, backed up by powerful neck muscles and a powerful body, made *Triceratops* a formidable opponent to any carnivorous dinosaur that chose to attack it. *Triceratops* had to be well protected for it was a contempory of the giant carnivore, *Tyrannosaurus.*

Two skulls of *Triceratops* are exhibited in the west wall cases (45, 46). One of them (45) shows the under side of the skull and particularly how the great frill is developed behind the occipital condyle—the articulation of the skull on the backbone.

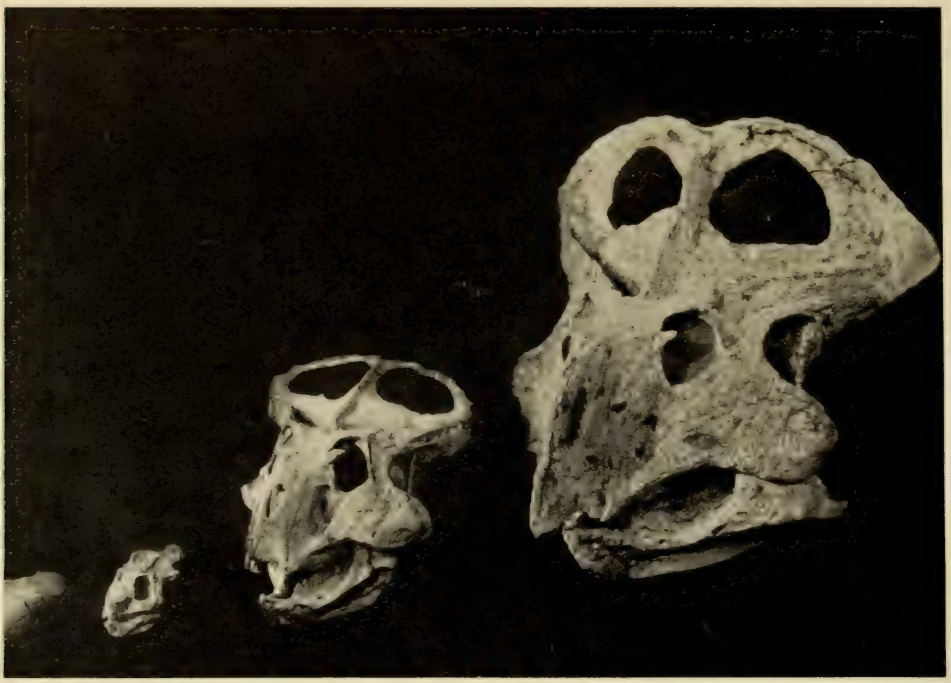
There were several different kinds of horned dinosaurs in Upper Cretaceous times, the differences between them being most apparent in the development of the skulls. On the west wall is a skeleton of *Monoclonius* (47), a ceratopsian having a long, upright nasal horn but no horns above the eyes. A skeleton with fossilized skin is also on exhibit in the Cretaceous Hall (48). At the north end of the Cretaceous Hall is a skeleton of *Styracosaurus* (49), in which the nasal horn is large and the fenestrated frill is decorated with long spikes projecting out from its borders. Other types of ceratopsians are represented in the exhibits by skulls; *Pentaceratops* (50), *Anchiceratops* (52) and *Ceratops* (51). This latter is represented by two skulls that probably are male and female, since in one skull the brow horns are much larger than they are in the other skull.

There were several successive associations of faunas of dinosaurs in Cretaceous times. In beds of lower Cretaceous age are the dinosaurs found in the Cloverly formation, camptosaurs and sauropods. In beds of Upper Cretaceous age are several horizons, notably the Edmonton and Belly River formations of Alberta and the Lance and Hell Creek formations of Wyoming and adjacent states. In the Edmonton-Belly River series are found the theropods, *Struthiomius* and *Gorgosaurus,* the duckbills *Corythosaurus* and *Parasaurolophus,* the armored dinosaur *Ankylosaurus* and the ceratopsians *Monoclonius* and *Styracosaurus.* In the Lance-Hell Creek series are found the giant carnivore, *Tyrannosaurus,* the duckbill *Trachodon* and the ceratopsian *Triceratops.*

The first of the horned dinosaurs, *Protoceratops,* from the Cretaceous of Mongolia. In this primitive member of the group, the horns were as yet undeveloped. Below, a nest of eggs of *Protoceratops,* as they were discovered by the Central Asiatic Expedition of the American Museum of Natural History.

AMNH photos

At each stage there was a balanced association of animals; of plant-eaters and meat-eaters, of hunter and hunted. The same theme runs through geologic time, with variations at each level. If this fact is kept in mind, the great array of dinosaurs as displayed in the dinosaur halls will have an added meaning; the various adaptations seen in the evolving lines will take on a significance that otherwise, without this correlation of associated animals would be lost. If each dinosaur is viewed with some understanding of its environment and of the animals that lived around it, the appreciation of its form and structure will thereby be increased and clarified.



An egg and thre growth stages of *Pr toceratops,* showin the development the bony frill over th neck which is charac teristic of the horne dinosaurs.

AMNH photo

The End of the Dinosaurs

In late Cretaceous times, between 60 and 70 million years ago, the dinosaurs were dominant throughout all of the continental areas. Then, with the transition from the Cretaceous period to the Paleocene period of the Cenozoic Era the dinosaurs became completely extinct. That was about 60 million years ago.

What are the reasons for the extinction of the dinosaurs? This is a question to which no completely satisfactory answer can be given. In brief, we can say that the dinosaurs were unable to adapt themselves to changing conditions of environment, of food supply and of competition from other animals, and so they disappeared. The continents, which had been rather uniformly tropical and subtropical during Mesozoic times were becoming more varied. The plant life was changing. Climatic conditions were changing, and the uniform temperatures of the Mesozoic were giving way to the more varied and the fluctuating temperatures of the Cenozoic.

Probably the causes for extinction of the dinosaurs were complex. What we do know is that these great reptiles died out rather suddenly in the geologic time sense, and the small furry warm-blooded mammals, which during the age of the dinosaurs were so insignificant, became the dominant animals on land, the inheritors of the earth. Thus passed a long and great stage in the

iratops was admir- equipped for de- e fighting.
AMNH photo

history of life on earth and thus began a new stage, the age of mammals, the age in which we are now living.

Dinosaurs in the Field and Laboratory

The scientific study of dinosaurs began about one hundred years ago. Before that time dinosaur bones undoubtedly were found by people all over the world, but the true relationships of these fossils were not recognized. In fact, many of the legends of giants that are so prevalent among primitive people, and that survived among our own ancestors even in medieaval times, frequently were based in part upon the discovery of dinosaur bones. These fossils were objects of curiosity and speculation.

With the rise of systematic zoology and geology as formalized sciences toward the end of the eighteenth century, the serious study of fossils began. Fossils, which had been curious objects for wealthy noblemen to place in their private "cabinets" or museums, became objects of true scientific significance, worthy of study by scholars. Thus it follows that the collecting of fossils was systematized and techniques for handling and preserving these objects were developed.

Some of the questions most frequently asked of the paleontologist are "How do you find fossils? Do you go out to the middle of a field and begin digging? How do you know, when you go out on a collecting trip, that you are going to find anything?"

Like so many aspects of modern life, the collecting and study of fossils is a highly specialized profession that calls for much training and experience. It cannot be undertaken on a hit or miss basis.

The trained paleontologist never goes out into a field, willy-nilly, to begin an excavation for fossils. He digs where there are evidences of fossils, that is, a place where he finds scraps of fossil bones or shells to indicate the possible presence of fossils below the unweathered surface of the ground. This means that the paleontologist generally does a good deal of looking around and searching before he finds a promising "prospect." He must tramp back and forth across the region in which he is working, looking especially along cliffs or in canyons or over badland surfaces, where the fossil-bearing rocks are exposed to the processes of weathering. What is more, the paleontologist does not

search indiscriminately over all of the exposed rock surfaces in an area, but rather he limits himself to the strata or "horizons," which through a method of observation, deduction and elimination he establishes as the rocks in which fossils occur. For it must be said that fossils do not occur uniformly distributed, but rather are limited to certain rock strata, and generally to certain geographic areas as well.

This is the answer to the last question posed above—"How do you know that you are going to find anything?" You don't know. But by a combination of hard work and good judgment the search for fossils is never exactly a blind search; the chances are all in favor of positive results provided the paleontologist spends a sufficient amount of time in the field, and provided he works intelligently, basing his efforts on his own experience and upon the experience and knowledge of those who have gone before him.

The search for fossils is a constant adventure. There are many heartbreaking days or weeks during which nothing of consequence is found. But sooner or later a good prospect is discovered, something that compensates for the hours of hard labor that have gone into the search.

When a likely looking discovery is made, there is still much work to be done before the fossil can be removed. Fossils are commonly fragile and brittle even when completely mineralized. Therefore the removal of large fossils is frequently a painstaking operation that requires some time and patience, and the use of well-established techniques.

When, for instance, a dinosaur skeleton is discovered, the "overburden" or rock above it must first be removed, a job that may require quite an extensive quarrying operation. Then the bones are partially exposed by chiseling away the rock next to them, so that the limits of the specimen can be determined. As the fossil is exposed, it is treated with thin shellac, to prevent deterioration of the specimen.

Then there comes the job of taking the specimen out of the ground. If it is a skeleton of some size, it is taken out in separate blocks, each block being made small enough to be handled conveniently. The exposed fossil bone is covered with thin rice paper, which is shellaced to the bone; this gives the fossil added strength. Then the entire block is covered with a casing of burlap dipped in plaster, which when hardened makes a stiff, immobile jacket or "cinch;" this prevents the block from disintegrating during the handling. Usually, the top and sides of the block are exposed, shellaced, treated with rice paper and cinched while it is still in place. After

Restoration of *Triceratops,* the last of the horned dinosaurs. The seven-foot skull with its flaring "collar" was fully one-third the entire length of the animal.

Restoration by Charles R. Knight, copyright the Chicago Natural History Museum.

this is done the block is undercut and turned over and the bottom surface is similarly treated. If the block is very large, wooden splints are fastened to the outer jacket to give additional strength.

The blocks are carefully marked to identify them and proper entries are made in the field notes, after which the fossils are packed in straw in wooden boxes, for shipment to the museum or university or laboratory, where they are to be studied.

At the museum the entire process is reversed. The plaster jacket is stripped from the blocks, and then in the laboratory the fossil is really cleaned and made ready for study. This is a process that occupies much more time and labor than the collection of the specimen. Consequently, when the fossil finally is in shape for study it represents the expenditure of a considerable amount of effort on the part of the paleontologist and the technicians who work with him.

This is not the end of the story. An unstudied, unidentified fossil has only a potential value. The true value of the fossil is represented not by the object itself, but rather by a combination of the object plus what we know about it through careful research. In a way, a fossil is only a means toward an end, the end being the increase of our knowledge as to the past life of the earth. Therefore, in a properly conducted museum or paleontological laboratory the fossil must be studied and named, after it has been thoroughly prepared. And if it is of sufficient importance, it becomes the object of careful research, which research eventually is published in some scientific journal. So it is that the true measure of a museum or of a paleontological laboratory is not in the collections themselves, but rather in the publications that have been issued as a result of studies made on the collections. Research and publications are the final ends of the long process that began with a careful hunt through canyons or badlands for fossil remains.

Needless to say, the best fossils are placed in the exhibition hall, if there is an exhibition hall, where they can be seen by all. But only the best are thus exposed to public view. The bulk of the material collected by the paleontologist is retained in storage for future study and reference. Like the books in a library stack, the fossils in storage are available on call for the serious student of the past life on the earth.

This is the story of hunting the dinosaurs, of digging them out, of preparing them in the laboratory, of studying them and finally of placing some of them on exhibit to illustrate what they are and what we know about them. The hunting and collecting of

Skeleton of *Styracosaurus,* another horned dinosaur with spikes on the frill.

AMNH photo

the fossils form the more "romantic" part of the story, the part which appeals to most people. But the preparation and study of the specimens is equally important—indeed it is the unromantic and the seemingly tedious research that establishes the final worth of the paleontologist's efforts. All the rest of the story is directed toward this end. And it is through unremitting and careful research that we have learned what we know today of the past history of life. Research brings the dry bones to life, it permits us to project ourselves back in time, and to see the earth as it once was, to see vistas of life through the ages. Thus we have learned to know the dinosaurs.

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When indications of fossils are discovered, the overlying rock is removed and the fossilized bones are thus exposed. As they are exposed, they are treated with shellac to harden them. Careful notes are kept, and pictures are usually made before the bones are removed from the position in which they were originally found.

AMNH photo

MNH photo

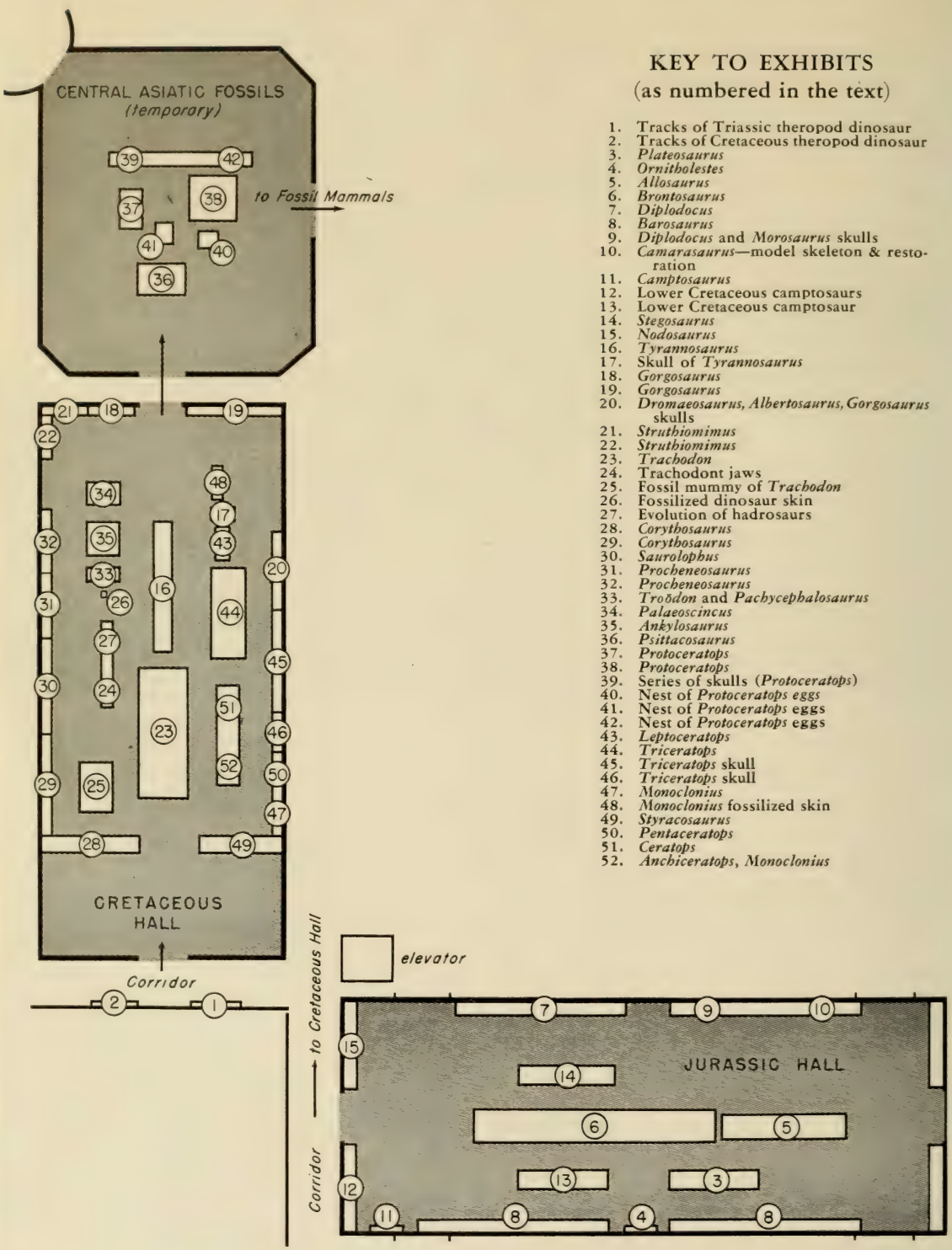
fter the exposed bones have been ardened, they are encased in a hard cket of burlap dipped in plaster of aris. A layer of tissue paper is enerally shellaced over the bones efore the burlap and plaster are pplied.

fter the fossil is completely encased the burlap and plaster jacket and e jacket has hardened, the specimen n then be removed from its original osition and packed in a box for ipment to the museum.

AMNH photo

DINOSAUR HALLS

Fourth Floor



KEY TO EXHIBITS
(as numbered in the text)

1. Tracks of Triassic theropod dinosaur
2. Tracks of Cretaceous theropod dinosaur
3. *Plateosaurus*
4. *Ornitholestes*
5. *Allosaurus*
6. *Brontosaurus*
7. *Diplodocus*
8. *Barosaurus*
9. *Diplodocus* and *Morosaurus* skulls
10. *Camarasaurus*—model skeleton & restoration
11. *Camptosaurus*
12. Lower Cretaceous camptosaurs
13. Lower Cretaceous camptosaur
14. *Stegosaurus*
15. *Nodosaurus*
16. *Tyrannosaurus*
17. Skull of *Tyrannosaurus*
18. *Gorgosaurus*
19. *Gorgosaurus*
20. *Dromaeosaurus, Albertosaurus, Gorgosaurus* skulls
21. *Struthiomimus*
22. *Struthiomimus*
23. *Trachodon*
24. Trachodont jaws
25. Fossil mummy of *Trachodon*
26. Fossilized dinosaur skin
27. Evolution of hadrosaurs
28. *Corythosaurus*
29. *Corythosaurus*
30. *Saurolophus*
31. *Procheneosaurus*
32. *Procheneosaurus*
33. *Troödon* and *Pachycephalosaurus*
34. *Palaeoscincus*
35. *Ankylosaurus*
36. *Psittacosaurus*
37. *Protoceratops*
38. *Protoceratops*
39. Series of skulls (*Protoceratops*)
40. Nest of *Protoceratops* eggs
41. Nest of *Protoceratops* eggs
42. Nest of *Protoceratops* eggs
43. *Leptoceratops*
44. *Triceratops*
45. *Triceratops* skull
46. *Triceratops* skull
47. *Monoclonius*
48. *Monoclonius* fossilized skin
49. *Styracosaurus*
50. *Pentaceratops*
51. *Ceratops*
52. *Anchiceratops, Monoclonius*

MAN AND NATURE
PUBLICATIONS

Science Guide No. 70

#71

The Maoris and their Arts

by

MARGARET MEAD

Guide Leaflet Series #71

Fig. 1 MAP OF NEW ZEALAND

The areas marked on the accompanying map correspond roughly to the more important groups of Maori tribes.

I. THE NORTHERN PENINSULA. MOST IMPORTANT TRIBE, *Ngapuhi.*
II. BASIN OF WAIKATO RIVER AND ADJOINING COASTS. MOST IMPORTANT TRIBE, *Waikato.*
III. WEST COAST AREA. MOST IMPORTANT TRIBES, *Taranaki* and *Whanganui.*
IV. BAY OF PLENTY AREA. MOST IMPORTANT TRIBE, *Arawa.*
V. WAIAPU AREA. PRINCIPAL TRIBE, *Ngati-Porou.*
VI. UREWERA COUNTRY. *Tuhoe* TRIBE.
VII. EAST COAST AREA. *Ngati-Kahungunu.*
VIII. SOUTH ISLAND. *Kau-Tahu* TRIBE.

The Maoris and Their Arts

by

MARGARET MEAD

GUIDE LEAFLET NO. 71

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Introduction

MAORI IS the name given to the native people whom the Europeans found living in New Zealand at the time of discovery. In language and custom, they are grouped with the other Polynesian peoples who inhabit the Pacific Islands between Hawaii and New Zealand. They are believed to have migrated to New Zealand from Southeastern Polynesia in the twelfth and thirteenth centuries.

Coming to the more rigorous climate of New Zealand from the tropical, unexacting island environment, the Maori had many new problems to solve. He had not brought with him the pigs and fowls which formed an important element of diet in his earlier home. The breadfruit tree, the cocoanut palm, the sugar cane, could not be grown in New Zealand, depriving him not only of an important part of his food supply, but also forcing him to find substitute materials for all the uses to which his ancestors had put palm leaves and sugar cane leaves; for basketry, for thatch, for house blinds, for mats. Where the Polynesians used cocoanut oil he had to learn to use shark oil and berries from the *titeki* tree (*Alectryon excelsum*).

Although in remote times the ancestors of the Maori probably knew of the loom, its use had been abandoned in favor of the simpler process of beating out the bark of the paper mulberry tree to make *tapa*, bark cloth. In the South Sea island cases, and especially in the Hawaiian case, are pieces of *tapa*, examples of the high degree of perfection to which the Polynesians had brought the art. But the paper mulberry tree never flourished in New Zealand, nor was the thin, paper-like *tapa* adapted to the more rigorous winters, so the Maori had to learn to dress flax and weave it into clothing. Although a plant related to that producing the *kava* root grew in New Zealand, the Maori did not make *kava;* the disuse of the ceremonial drink of Polynesia changed the aspect of many of their ceremonies, where eating a sacred food replaced the ceremonial *kava* drinking.

Although they succeeded in domesticating the *kumara* (the sweet potato), the taro, and the yam, the *kumara* was only grown as far south as Temuka in South Canterbury, and taro and the yam no farther than Cook Straits. The more southern population (which in New Zealand means the inhabitants of the colder part of New Zealand) had to eke out a meager livelihood from hunting and fishing and never became very numerous, the population of North Island being almost twenty times as dense as that of South Island.

The inhabitants of different parts of New Zealand developed many local characteristicts, owing to such considerations as the presence of workable stone for implements and weapons, a food supply which could support a denser population, etc. The most marked difference lies between North and South Island. Most of the early travelers were struck by the characteristics of the North Island Maori and the beautiful and elaborate carving which has so much in common with the art of the Western Pacific, particularly with the Massim and Sepik River areas in New Guinea, and with the Solomons. North Island carving is distinguished by the use of curvilinear designs, particularly in the form of elaborate spirals; while South Island carving is simple and prevailingly rectilinear. Most of the material in the Museum is from the North Island Maori and differs strikingly from the material culture of the other Polynesian groups represented in the hall.

The Maori were divided into family groups, several of which united together formed a *hapu* or local group; while a number of *hapu* constituted an *iwi* or tribe. They lived in fortified villages, surrounded by a stockade or several stockades of tree trunks bound together with sturdy vines. One tribe

might be scattered about in many villages. Each village had its own chief, who with his near relatives, both male and female, constituted the local aristocracy. The highest honor was reserved for the *Ariki*, the sacred high chief of the tribe, the eldest son of the eldest son of the highest family, who traced his descent back to the gods and was held in extreme respect and awe. Next to the chiefs ranked those who possessed great special ability as priests, diviners, carpenters, tattooers, or warriors, and beneath them came the landless gentlemen, who nevertheless were too haughty to carry loads upon their backs when the work could be delegated to a woman or a slave. The slaves were prisoners of war, who, carried away into a strange land, were without prestige because their deified ancestors were believed to have entirely disowned them.

The religious life of the Maori was intimately bound up with the idea of taboo, the idea that certain persons, places, acts, were sacred and dangerous. The imposition of taboos for the protection of the food supply or the building of a canoe, and the lifting of these taboos was the work of the priest. The priests were not organized, they were priests of occasions, a birth, a marriage, a harvest, and served the separate deities who presided over the forest, the sea, the traveler, according to the demands of the particular event. A priest's training involved a long apprenticeship during which he was taught esoteric lore and all the prescribed ceremonial procedure and long chants which he needed in his priestly office. In addition to the invocation of the high gods, the Maori magician and indeed the ordinary Maori as well lived his whole life in constant reference to the ghosts, particularly the ghosts of his ancestors. These ancestral ghosts were believed to have great power of assisting the living, and to exercise a jealous watchfulness lest their descendants break any of the tribal taboos.

Even before he obtained European tools the Maori produced works of art which rank very high in the woodwork of the primitive peoples of the world. The high esteem in which the artist was held and the fact that work dignified rather than demeaned a chief probably had a great influence in producing such beautiful craftsmanship. With the introduction of steel tools, it was no longer necessary to take great pains; the poorest workman could carve more quickly with the new tools than a virtuoso with the old ones. A great deal of inferior work was produced: a sample of such work is the storehouse in the center of the hall. In this house glaring color and mechanical, stereotyped decoration have taken the place of the rich color and highly stylized, but lovingly executed work of the older artists.

Work in Greenstone

MAORI ART owes much of its individuality to the existence in New Zealand of *nephrite*, a form of jade usually referred to as greenstone. It was found only on the South Island and the northern Maori had to obtain it by raids or through barter. Even the smallest pieces were greatly valued and the fragments of a large greenstone object which had been broken were reworked into ear pendants and shoulder ornaments.

The greenstone—of which the Maori distinguished many varieties according to color and relative translucency—was found in western river beds either as pebbles, which could easily be carried away or as boulders like the large one on which the Maori figure

stands, which had to be broken up into workable pieces by the use of heavy stone mauls. The broken pieces were sawed to the required dimensions either by blades of trap rock or by thin sheets of sandstone. The process of polishing was carried out by movement back and forth on a hollowed sandstone slab, into which water was allowed to drip steadily from a suspended calabash. For making holes a pumpdrill was used, very similar to the drill exhibited in the Samoan case, but lacking the rigid arm. Chert, flint, or quartzite drill points were used; and the hole was drilled first from one side, then from the other. The tubular drill point was unknown, but it is believed that a wooden point was sometimes used, requiring the aid of sand and water. Most of the processes are illustrated in the greenstone exhibit.

Although most artifacts made of greenstone were also manufactured in other materials, there are two classes of objects characteristically made in greenstone—weapons of two types, and various ornaments, the most famous of which was the *hei-tiki* (Fig. 2). The weapons are described in a later section. As adze blades of greenstone were frequently perforated and worn around the neck as ornaments, when not in use, students of Maori art feel that the peculiar grotesque form of the *hei-tiki* is the result of the artists' attempt to impose the shape of the adze blade upon the human figure. Similarly the ear-drops may be traced to the custom of wearing small greenstone chisels and gouges as ornaments, while the crescent-shaped ornament has an ancestor in the bone needle, worn suspended from the shoulder. Two important forms of greenstone ornament, the *peka peka*, or bat-shaped form, and the spiral-shaped *manaia* are not represented in the Maori collection. The evolution of these various greenstone objects from tools to ornaments is probably in great part attributable to the use of a precious stone as material for implements.

Greenstone plays a major role in Maori myth and legend. A characteristic tale explains the curious translucent quality of the form of nephrite known to mineralogists as *bowenite*. Tamatea, a famous mythical navigator, was deserted by his wives, their canoe capsized, and they were turned into blocks of greenstone. Tamatea wept so copiously over one of these blocks that his tears penetrated the stone, and gave it the quality which the Maori name *tangiwai*, or "tear drops."

Fig. 2 HEI-TIKI. Grotesque human figure carved from greenstone.

Greenstone ornaments and especially *hei-tiki* were kept in memory of dead friends and ancestors and ceremonially wept over by mourners. Greenstone weapons were cherished through many generations and were believed to have been endowed with stupendous power derived from the famous chiefs who had used them, and the battles in which they had played a part. They were

used in the ratification of treaties and as a ransom price for the life of a captive or the head of a dead chief.

As they made their most valued weapons of greenstone, so also the Maori found it their best figure of speech for the blessings of peace, which they called their "greenstone door."

The great trees which were to be used for the body of a canoe, or the ridge pole of a house, and from which the decorated house slabs and side strakes of a canoe were to be hewn, were sometimes selected years before they were to be used, and space cleared about them as a sign that they were already dedicated to a particular purpose. Months before

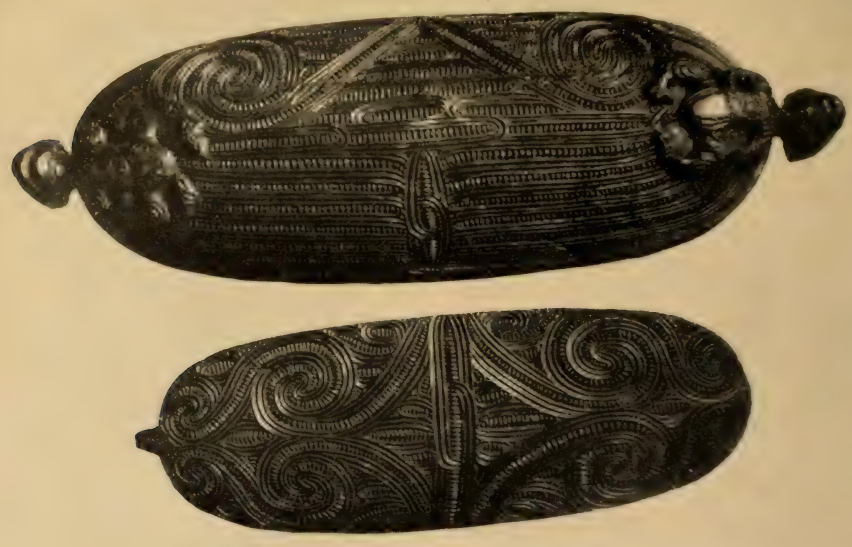

Fig. 3 WOODEN BOX USED FOR STORING FEATHERS. *a*, Lower surface of box, visible when it is suspended from the roof; *b*, Lid.

Woodwork

ALTHOUGH the Maori showed his skill as a wood carver in the decoration of every object which he used, digging-sticks and pigeon snares, small wooden boxes for storing feathers (Fig. 3), adzes, clubs for war and display, his finest work is found in the decoration of war canoes and the great carved communal houses which were the pride of a northern Maori village.

the work was to start crops were planted near the trees, which might be miles from the village. When the crops were ready for the harvest, the chiefs, the carpenters, their families and the slaves who were to do the bulk of the rough work, all moved into temporary houses near the selected trees. A ceremony in which the tree was symbolically struck with a leaf shaped like an adze, and a sacred fire kindled from the first chips cut from the tree, removed the sacredness of the tree and reconciled Tané, the god of the forests, to the loss of one of his children. Cutting the great *kauri* pines was slow work —a scarf was first cut and then part of the wood below it was charred with a carefully

tended fire, after which the charred timber was hacked out with stone adzes. Burning and adzing were repeated until the tree fell. In regions where good stone for tools was not available fire was used more extensively. Though the wooden wedge was known to the Maori, he had no timber which would split like the white cedar of the Northwest Coast. Instead he had to hew a log down to the required thinness. Hauling the great logs for many miles over rough trails and through steep gulches was accomplished by means of stout ropes and a series of wooden skids. Hauling chants with stanzas of long words for slow hauling and short words for quick, kept the hauling crew working in unison and with spirit.

In the village, building either a house or a canoe was also a sacred process. No woman might approach the scene; dogs were tied up for fear their intrusion would profane the work; and no food could be cooked on a fire burning the chips from a sacred carving. The carving of a house or canoe might take years to complete, as it was necessary to work very slowly for fear that the wood would crack. The finishing touch was given to house or canoe by a coat of red paint. The parts to be painted were carefully cleaned, sized with the juice of sowthistle and a native shrub, and then painted red with a mixture of oil and burnt ochrous earth, or black with a mixture of oil and soot. The paint brush was of flax fiber, except for the very delicate work, when a stiff bird feather was used.

Houses

THE FUNCTIONAL division of houses was within the village group rather than within the household, even the individual cookhouses were sometimes united in groups. The great carved houses were sometimes classified as council chambers, sacred houses for the instruction of the young men, guest houses, and houses where the whole tribe slept in time of war. Storehouses were highly decorated and very taboo. Special houses were erected for the initiation of the chief's son into the priesthood and for the birth of a child of rank. But a large number of specialized houses within the household establishment does not seem to have occurred, although chiefs had separate houses for their respective wives. Storehouses were tribal, the possession of the chief, or sometimes individual in the case of the rough, half-sunken house.

Maori houses present a strong contrast between the elaborate houses of assembly, which were beautifully constructed and highly decorated, and the dwelling houses, in which the people—even the chiefs for whom the great houses were built—lived. The essentials of the framework, however, were the same for all these houses, except that in the poorer ones the broad barge boards were sometimes missing. The window, placed beside the door, seems to have been present in even the smallest houses. The groundplan was oblong, the ends gabled, the sides low under the projecting eaves. The low doorway and window aperture opened out onto a veranda. The smallest huts were six to ten feet long and five to eight feet high. The ridge pole was attached to or inserted in two end posts, forked to receive it. Small sticks were fastened to the frame with flax withes; over these was laid a covering of rushes and an outer thatching of spear grass. The better houses were lined with bark and some of them were sunk a foot or two below the surface-level of the ground. The roof, which sloped in an angle of between thirty and forty-five degrees, projected at each end to form a veranda; light poles were placed over the thatch to keep it in place. These small houses contained fireplaces also. Indeed, there were no

distinctions between these houses and the great carved houses, except in size, choice of materials, and decorations. Still ruder huts, only thatched on the windward sides, were used by travelers. Canoe houses were long and sometimes presented a vaulted appearance. The ceremonial storehouses were raised on posts and their small doors were contracted at the top.

the supporting posts and to the rafters by lashings and wooden pins.

The groundplan of the house was squared by measuring the diagonals. The side posts, which were of such height as to give the roof a pitch of about thirty degrees, were graduated to correspond to the slope of the ridge pole. They were heavy planks, one to three feet wide, and three to nine inches

Fig. 4 A FORTIFIED VILLAGE, showing highly carved storehouse and carvings on the tops of the palisade posts.

But the main effort and ingenuity of the Maori was expended on the *whare whakaira*, or carved house (Fig. 4), which was often built as a memorial of some great event, such as the birth of an heir to the principal chief. These houses varied in height from twelve to twenty feet. The main weight of the ridge poles was borne by two heavy posts, the rear one slightly higher than the front. A central pillar, lighter than the end posts, supported the middle of the ridge pole. These end posts might be either slabs or whole trunks of trees. The ridge pole was about ten feet longer than the house. It was fastened securely to

thick, with rabbetted edges and a semi-circular depression in the top to receive the rafters. They leaned slightly inward and were buttressed behind by stout pieces of rough timber which were lashed to eyes in the upper ends of the slabs.

A slender stringer ran the length of the house and was lashed to notches or holes in each slab. A wall plate, a board set on its edge, extended from one corner post to the other. Each end slab was lashed to this plate. A skirting board was formed by placing slabs in the intervals between the side slabs. The rafters were cut into a tongue to fit the

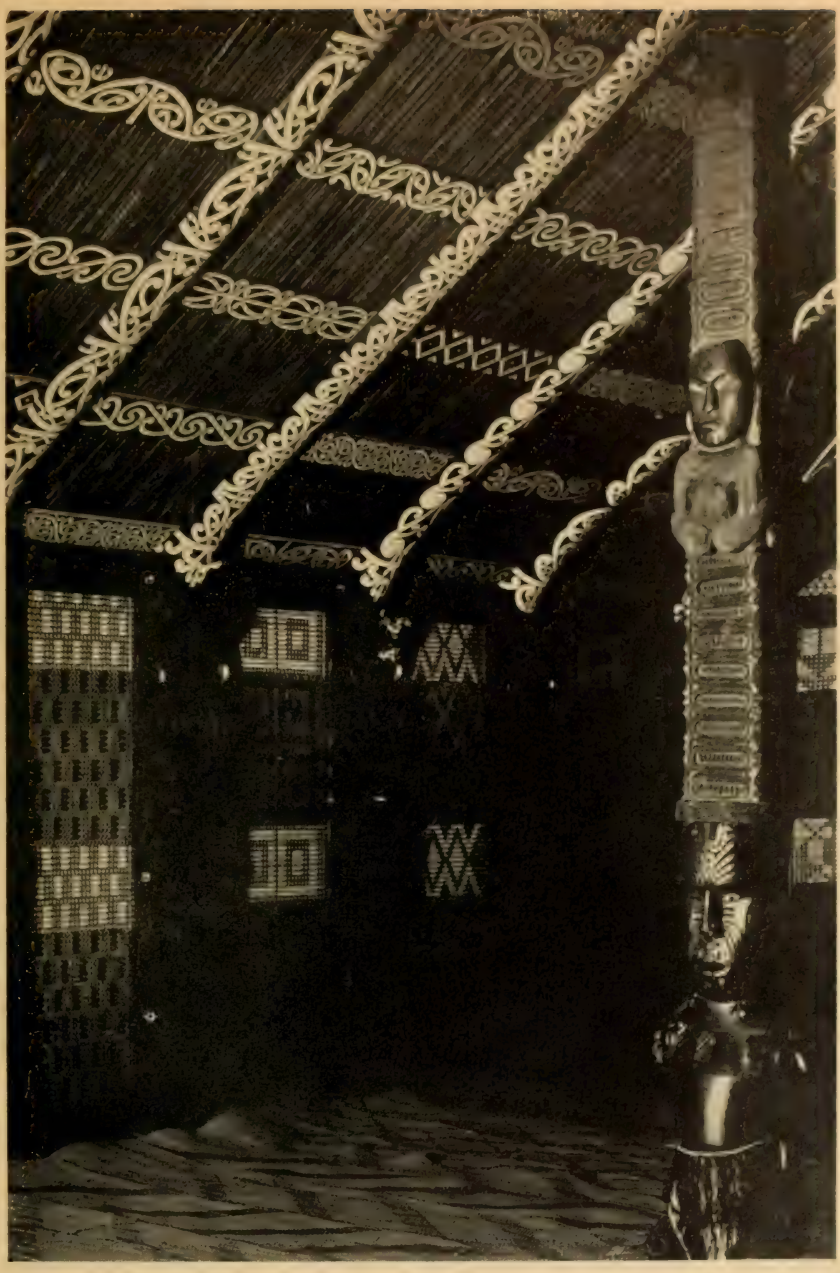

Fig. 5 INTERIOR OF A RECONSTRUCTED HOUSE

Fig. 6

CARVED HOUSE BOARD

Fig. 7

WOODEN FIGURE USED TO DECORATE A CARVED HOUSE

depression in the top of the side slabs and were lashed to them securely. Horizontal battens were lashed to the rafters and a trellis work of reeds covered these. The front of the roof was finished by heavy boards, which rested on similar vertical facing boards, placed at the front edge of each side wall. The ends of these barge boards projected beyond the house walls and were carved in a conventional filigree pattern.

The door was seldom more than two feet wide and four feet high. It consisted of a slab of wood about two inches thick, which slid along a grooved threshold into a recess built into the wall. The threshold was a piece of timber, about twice the width of the door and about a foot thick. Side jambs rested on this threshold and projected beyond it in each direction to form a molding. The window, about two feet square, was similarly constructed. It was usually so high that a man, sitting, could barely see out.

The wall spaces between the side slabs were filled with flax mats, or with reed battens; the horizontal laths, one-half inch to an inch wide, were lashed to the vertical reeds with colored grasses (Fig. 5). Bunches of bullrush leaves were sometimes inserted for warmth. Further layers of coarse grass completed the thatch. Horizontal poles, vines, or thick ropes, kept the thatch in place and sometimes several of these were placed one above the other in different layers. The ridge pole was bonnetted by a row of fern fronds, or by a thick bundle of long grass, bound over the rear end of the ridge pole and securely lashed to the ridge pole and rafters.

As Maori houses were not built on stone foundations the floor was simply beaten earth, strewn with rushes and ferns. The bed spaces on either side of the door were filled with ferns, and marked off by planks pegged to the floor. The fireplace was a hollow square enclosed either by a row of stones or by wood.

Each family group of houses was surrounded by a fence made with posts planted in the ground, to which horizontal rails were securely lashed. The whole village was surrounded by a large fence of this character, with periodic large posts carved to represent a defiant warrior. The smaller posts were notched at the top so as to resemble a human head. Inside this fence there was sometimes a lighter fence and within these excavated earthworks.

When the house was finished, it had to be formally consecrated. In this ceremony the priest tied a sacred shrub to the back center post and held a bundle of sacred shrubs in his hand. The charms followed a definite order; the first to propitiate Tané; the second, at which the priest ascended the roof, was to remove the taboo from the carver's sacred instruments and from the wood carved into images of the gods. Here the priest struck the various carvings of the

Fig. 8 DESIGNS PAINTED ON THE RAFTERS OF A HIGHLY DECORATED HOUSE. (After Hamilton.)

house with the shrub which he held in his hand. The third incantation was an appeal to the gods to make the house warm. The whole ceremony was known as "binding the *maro* (girdle) of the house." The priest then entered the house by a window and opened the door. The threshold was first crossed by three women of rank, so that food might be brought into the house with safety, and the ridge pole prevented from sagging.

Human sacrifices were offered at the building of a great house or the fence of an important *pa* (fortified village). In the latter case, a slave was buried under one of the posts. In the former, a member of the tribe was killed, sometimes the favorite child of the chief, the heart was cut out and eaten, and the body buried beneath one of the posts. Occasionally, a distinguished captive was sacrificed thus.

The decoration of the Maori house can be subdivided into carving, rafter painting, and reed work. Sometimes the carving was painted, especially in the case of the heavily carved slabs over the door and window, and on storehouses. When carving did occur in ordinary dwellings it was on the barge boards, the vertical facing boards, and sometimes on the broad piece of timber which faced the front of the veranda. A carved face was placed over the junction of the barge boards and occasionally a human figure placed above this. Storehouses were carved on the whole outside surface. Each separate panel of wood was treated as a decorative unit.

The outside was carved as described above, more elaborately in the case of the large houses. The slabs (Fig. 6) were carved on the inside in high relief into conventionalized human figures. A small human figure was carved in the round at the foot of the center pole. The panels (Fig. 7) between the side slabs were decorated with reed work in elaborate step and checker patterns. These were occasionally modified in an attempt to approximate to the designs of the slab carvings. The rafters were painted in red and white curvilinear designs (Fig. 8). Inlaid haliotis shell decorated the carvings.

The style was characterized, as in the case of canoe carving also, by extensive use of the double scroll, combined with conventionalizations of the human figure. There was a tendency toward intricate incidental decoration and towards treating the part of the object decorated as the unit. House carvings were occasionally decorated with feathers. Ornamental shrubs were sometimes planted around the houses.

Canoes

THE ONLY type of Maori canoe of which we have a full description is the single war canoe without an outrigger. Tasman, whose principal stay was at South Island, reports only double canoes, and in 1770 Cook speaks of some canoes being joined together and of the use of outriggers. But in 1840 Pollack, a most careful observer, could say that outriggers were unknown in New Zealand. The early double canoes were said to have been either connected by cross bars which left from two to two and a half feet between the hulls, or to have been only thirty inches apart. These early outrigger canoes, according to the descriptions in the mythology, were built of several boards lashed together, rather than the single strake characteristic of the historical type of Maori canoe, and carried platforms on which awnings were erected. The Maori also possessed a raft-like craft, constructed of bullrushes, similar to that found in the Chatham Islands.

The typical Maori canoe of historical times was built on the dugout plan. The keel was usually hewn from a single tree, occasionally the stern or prow section of the

hull was dovetailed on, and an immense strake fifteen or twenty inches wide produced the desired height. These side strakes were lashed to the keel with cords of flax, (the lashing being visible on both sides), and caulked with bullrush down. The seams were covered with battens which were also very long and jointed only once or twice. The stern and bow pieces were hewn out of single blocks of wood and attached separately. Carved braces were lashed across the canoe and a grating was fastened along the bottom of the canoe on which the rowers knelt. The sails were triangular, the largest canoes carrying two. The paddles were from four to five feet long and usually leaf-shaped, tapering to a point, and many variant forms occurred.

The decoration of Maori canoes falls into two classes, permanent and temporary. The permanent decorations were both carved and painted. The most elaborate vessels were richly carved, while the small fishing canoes were often merely painted. The bow and stern pieces were carved from single blocks of wood and the positions of the human figures they embodied were carefully stylized. The stern piece was from six to fifteen feet high and about fifteen inches across and rose almost perpendicularly; the bow piece was from six to ten feet long and about two feet across. At the base of the stern piece was a small carved figure, looking into the canoe, and above this at the termination of the two strengthening ribs was carved a still smaller figure. The whole stern piece was carved in a delicate filigree pattern of double spirals (Fig. 9). The figure-head consisted of a human figure, facing forward, and a mid-rib running back from the figure, carved in the same elaborate filigree as the stern piece. Behind the transverse slab terminating the filigree there was often a small human figure facing the canoe. On the flat part of the bow piece, beneath the filigree, lay the prostrate figure of Maui, a mythical hero. This figure-head was occasionally constructed of two pieces; the vertical midboard was then grooved into the block. The thwarts and strakes were carved also. The second class canoes had a figure-head with

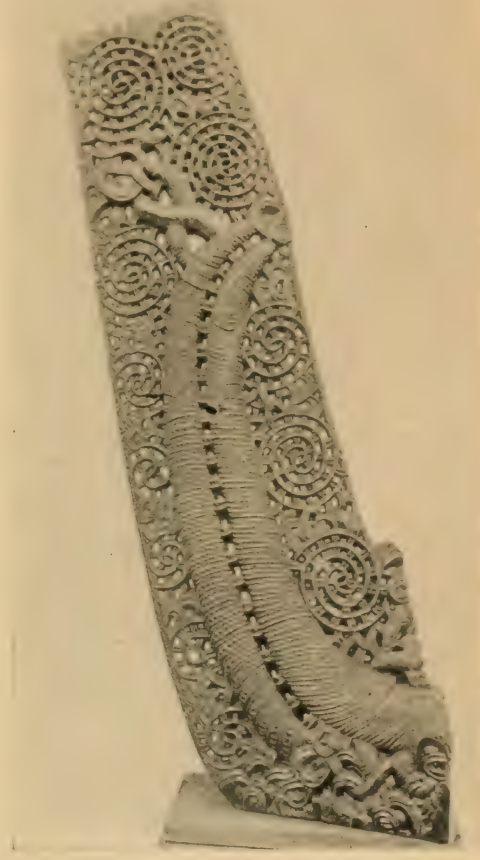

Fig. 9 CARVED STERN PIECE OF A WAR CANOE. (Reproduced through the courtesy of the Dominion Museum.)

protruding tongue which was less elevated than in the case of the war canoes. The forward and after sections of the body of the canoe were elaborately decorated with painted spirals and patterns resembling those of the thigh tattooing in red, black, and white. The second class canoe was painted

Fig. 10 CARVED CANOE PROW

red, and the third class, which boasted neither top sides nor carved stern and bow piece, was often painted. The battens which covered the seams were painted black and decorated with white feathers. The model in the American Museum has pearl shells inlaid in the carved work.

The temporary ornaments consisted of feathers fastened to ropes, which streamed from the top of the stern to the surface of the water. The prow was ornamented by two long curving wands, resembling antennae, tufted with albatross feathers.

A division of Maori canoes by function or by type of decoration produces identical classifications. The war canoes were most fully and elaborately carved; those used for traveling and fishing were plainer, with a figure-head of a human face with protruding tongue. There were rougher canoes, usually uncarved but sometimes painted. The largest canoes were built for war, but the other two types were not distinguished as to size.

The hull of the canoe was hollowed out inland in the forest. The wood was slowly burned away until the hollow approached

Fig. 11 WAR CANOE named *Te Toki a Tapiri*, Tapiri's Ax. (Reproduced through the courtesy of the Auckland Institute and Museum.)

The Museum has one very fine figure-head (Fig. 10) which shows the beautiful effect which the carver obtained when working within a strictly delimited convention. The Maori used two types of figure-head; the Museum specimen is of the more usual type, with the two large scrolls as the basic motifs of the filigree, and the grotesque figure with protruding tongue and arms extending backward. The stern piece on exhibition shows the characteristic strengthening of the filigree by the two curved ribs surrounded by filigree work of small scrolls. This is an unfinished piece: a completed stern has fine detail carving on the surfaces here left undecorated.

the desired size, when the use of fire was abandoned, and the workers proceeded more cautiously with adzes alone under the careful supervision of an expert. When the roughing-out process was complete a great feast was spread and the woman of highest rank in the tribal division mounted the canoe and ceremonially ate the food.

After the hull had been safely hauled to the village, it was sheltered in a shed built for the purpose. The men who worked in it wore special garments woven for them by some old woman of rank. These garments were left in the workshop for fear chips of the sacred wood might be accidentally carried away and contaminated.

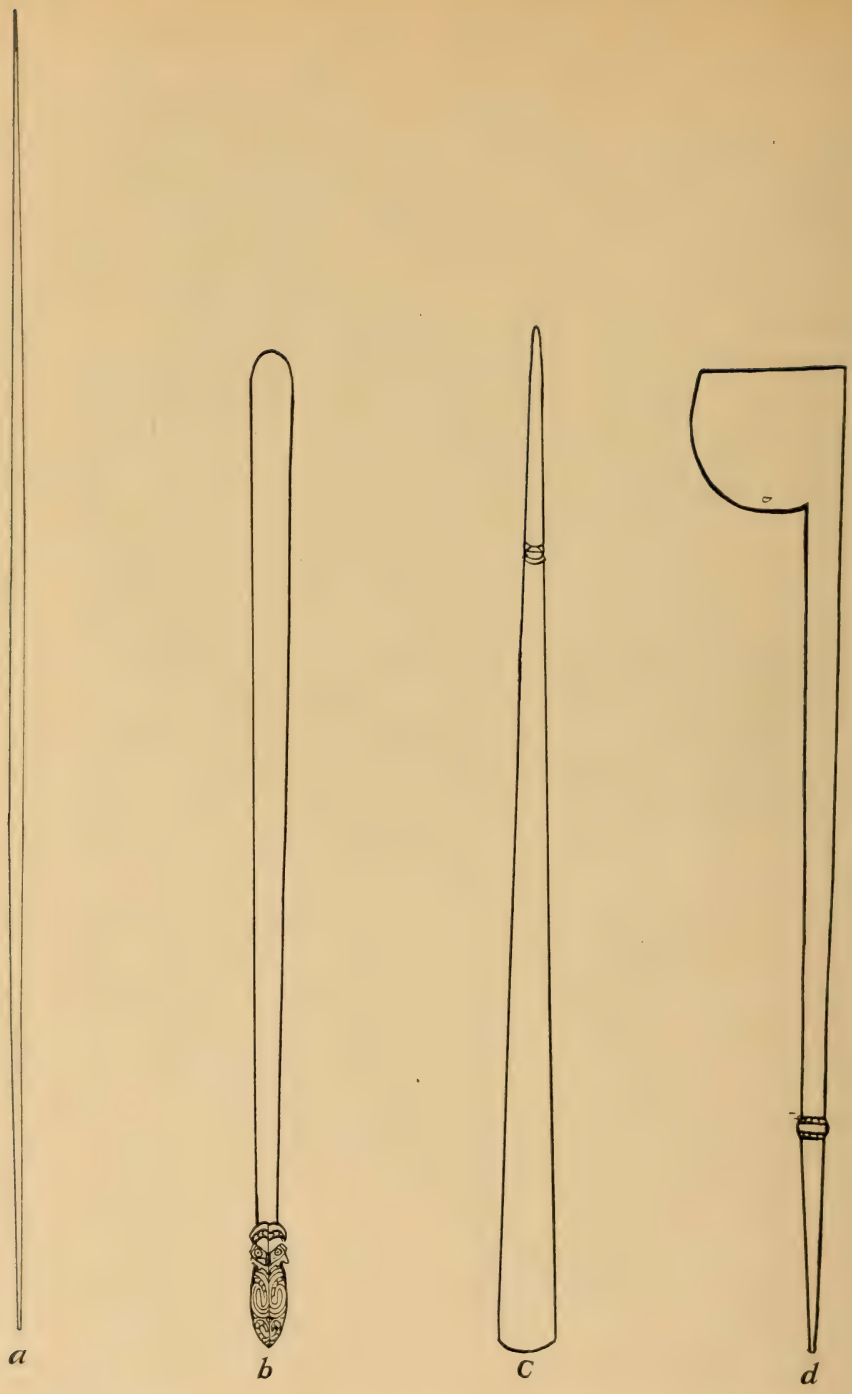

Fig. 12 WOODEN WEAPONS. *a, Tao. b, Hani. c, Pouwhenua. d, Tewhatewha.*

Before launching, a priest performed a ceremony to divine the fortune of the canoe. A special shrub was consecrated for this purpose and then pulled up; if the roots were unbroken, the canoe would be lucky. The figure-head of the canoe was struck with this shrub to remove the taboo, so that the gods. Sometimes the people chanted a welcome to the new canoe. One such welcome ran, "Come hither O Tané, let us go forth on the waters of *Pikopiko-i-whiti*, that you may be observed of all persons. 'Twas I who went and brought you hither from the great forest of Tané."

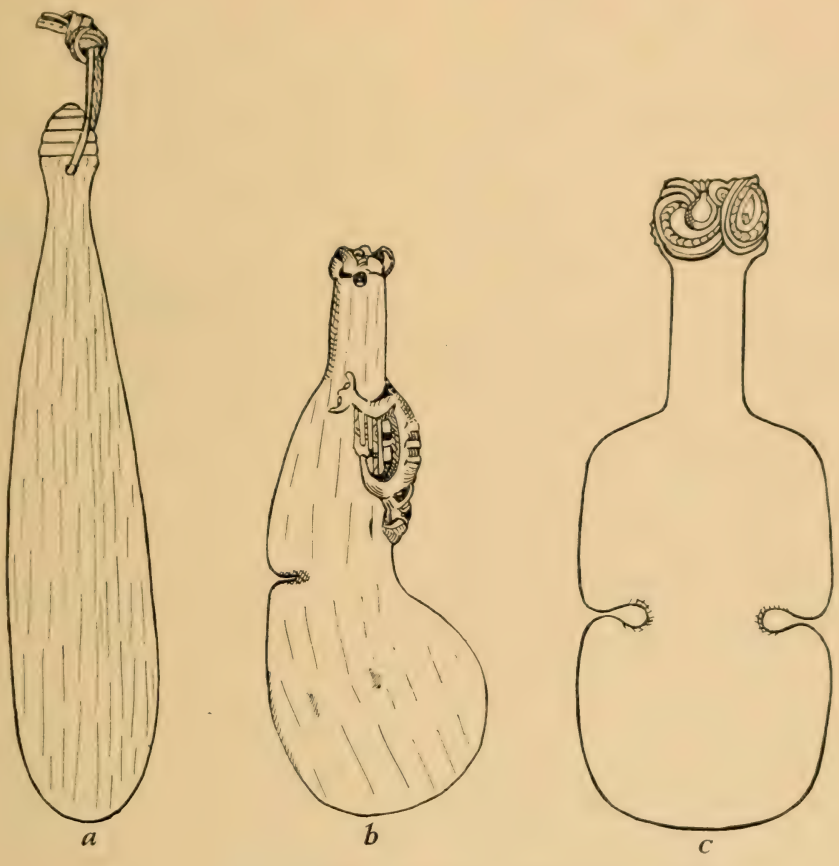

Fig. 13 THRUSTING WEAPONS. *a, Mere. b, Waka-ika. c, Kotiate.*

all the people might use the canoe without danger to themselves; a woman of rank again mounted the canoe and in future a woman might use it with safety. Sometimes a human sacrifice was made, a relative of the chief volunteering for the purpose. If no human sacrifice were made, the heart of a sparrow hawk was offered to the gods in its place. Then a priest chanted a special ritual over the new vessel, placing it under the care of

Weapons

THE PRINCIPAL weapon for actual warfare was the *tao* or spear (Fig. 12*a*) made of a single piece of hard polished wood. The common form was four to six feet in length; less usual types, measuring twelve to fourteen and sometimes as much as forty feet,

were used by several men as ramming rods. These longer spears (*huata*) had a rounded knob and a decoration of dog hair on the end. Other spear forms were barbed on one or both sides with the species of the sting ray, or had two or more points. Some tribes used a short dagger of whale bone.

The famous two-handed clubs are of three main types. The *hani* (Fig. 12*b*) is characterized by the carving at the butt end representing a human tongue ornamented with scrolls. The *hani* was decorated with a circle of cream-colored dog's hair, above a band of scarlet parrot feathers woven into a ground work of flax fiber.

The blade of the *pouwhenua* (Fig. 12*c*) is wider than that of the *hani* and the tongue motif is missing, but the handle is similarly decorated below the grasping point with a band of carving representing, often in a much degenerated form, two human faces. It was never decorated with feathers or hair.

The blow dealt by either *hani* or *pouwhenua* was delivered with either edge of the blade. In close hand-to-hand fighting, when an opponent had gotten within the guard, the pointed end of *hani*, *pouwhenua*, or *tewha tewha* (Fig. 12*d*) was used like the bayonet. But the blow of the *tewha tewha*, the ax-shaped club, was delivered with only one edge, the sharpened straight edge paralle with the handle, the ax-shaped expansion merely added weight to the blow. Where the head joins the blade a bunch of feather was tied through a small hole with a binding of flax. The *hani* and the *pouwhenua* ar both forms of one type of weapon, th divergence probably being a local phenome non; but the *tewha tewha* is allied to othe forms found in the Pacific—to the ben paddle-shaped clubs, one of which is ex hibited in the Solomon Islands case and th flaring center-ribbed club of Niué.

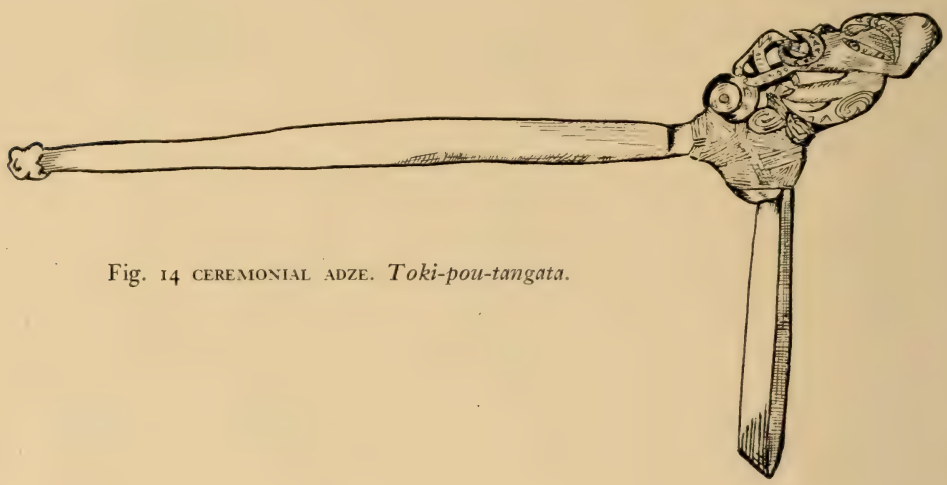

Fig. 14 CEREMONIAL ADZE. *Toki-pou-tangata.*

Patu is the name given to a group of thrust ing weapons made of greenstone, whal bone, and wood, all of which are character ized by a narrow neck expanding into flat blade with a cutting edge at the dista end of the weapon. The weapon was secured to the wrist with a thong of flax or leather the blow was delivered at close quarters with the uplift stroke toward the opponent' temple.

There are two chief types of variation in the *patu*, from the simple symmetrical blade of the *mere* (Fig. 13*a*) to the indented form called *kotiate* (Fig. 13*c*), of which there is an example in wood in the case of weapons and the *waka-ika* (Fig. 13*b*) in which one cutting edge has vanished and a carving of

a grotesque human figure has taken its place. The other variation is in the handle, developing from a simple perforation for the thong to an elaborate representation of the human head.

It has been claimed that all of these forms are local New Zealand developments of the adze blade, which occurs as a weapon in the extremely beautiful form of Fig. 14. The original location of the cutting edge was retained and the hand grip developed from the grip used in lashing the adze blade to a handle.

The ceremonial adze (Fig. 14), called a *toki-pou-tangata*, was characterized by the greenstone blade and the carved handle which carries a highly conventionalized decoration, the bird-headed man swallowing a snake.

Textiles

THE MAORI art of weaving is believed to be a local development having its origins not in the Maori's memory of a loom used before the Polynesians migrated into the Pacific, but rather in the processes of plaiting pandanus, hibiscus bark, and other basketry materials into mats and baskets. The inhabitants of other of the Pacific Islands brought this plaiting to a high degree of perfection: notable examples are the "fine mats" of Samoa, worn as clothing on ceremonial occasions, and the famous bed mats of the Hawaiians. But these were all plaited without even the most primitive form of loom. The Hawaiians also brought the art of netting to a high point of development, as may be seen in the foundation of the feather cloak exhibited in the center of the hall. The two twined weft, a true basketry technique, appears in garments from the Hervey Islands and the Tuamotus, and the Samoans use the support afforded by fastening the weft strand with which they begin their grass skirts to two firm supports—the waist of the worker and a house post.

But it remained for the Maori to form a very simple loom (Fig. 15) by planting two upright stakes in the ground and stretching a supporting weft line between them, and to apply the basketry technique of twining to the manufacture of cloth. They also, after abandoning the attempt to grow the paper mulberry and to utilize the bark of the New Zealand lace-bark tree, had to develop a technique for handling the New Zealand flax (*Phormium tenax*), from which all the garments were made, except the raincapes in which *kiekie* (*Freycinetia banksii*) and *toi* (*Cordyline indivisa*) were used.

In preparing the flax the outer surface of the blade was cut across with a shell and either scraped off painstakingly or peeled off with a quick jerk. If the inner surface was scraped very lightly it remained the rich golden color of the woven bag in the collection. For purposes of weaving clothing it was scraped more carefully. After being washed and scraped again and hanked, it needed only a further rubbing between the hands to separate the fibers, to be ready for use as warp material. At this stage it has the peculiar silken sheen so conspicuous in the material of the body of the undecorated cloaks. For the soft inner surface of cloaks, on which ornamental tags and feathers lessened the necessity for a beautiful texture, the flax was washed again and beaten on a flat stone with a stone pounder.

The flax cord was prepared by rolling it on the bare thigh with their right palm, with two movements—one away, the second towards the body. When a two-ply cord was needed, two equal portions were rolled together, but kept separate in the motion away from the body, and twisted together in the return stroke.

The Maori used no spindle and no suspension beam at the top of their looms such as

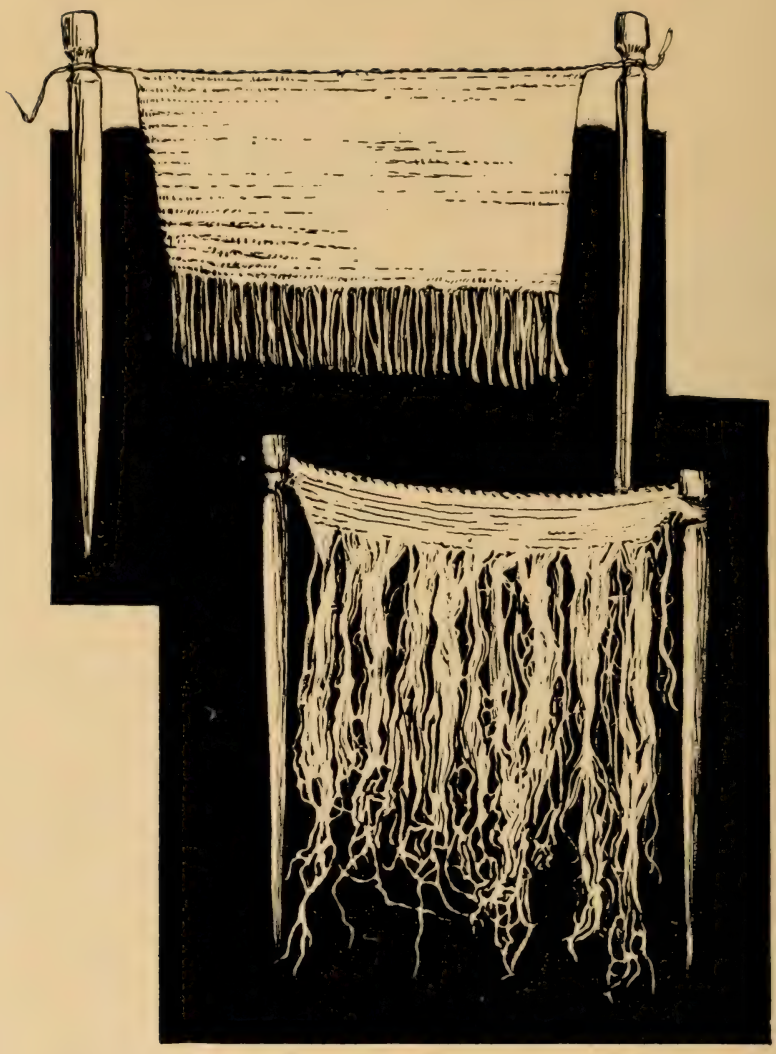

Fig. 15 LOOM SHOWING STAKES AND METHOD OF SUSPENSION OF WEB.
(Reproduced through the courtesy of the Dominion Museum.)

were used in the looms of American Indians. The place of this beam was taken by the first weft line, called the "ridge pole weft," in which warps of appropriate length had been twined. Only after this line was made did the worker stretch it between the two weaving poles, eighteen inch posts, carved or knobbed at the top, and pointed at the bottom. In the weaving of important garments it was customary to release the right hand stick and roll the work up at sunset, and it was etiquette to release the stick and make a feint of rolling up the work when a visitor approached.

Each weft line was doubled around the first left hand warp and worked horizontally across and knotted at the right hand side, or turned and knotted a few threads in. Each warp had to be handled separately; there was no shedding device of any sort. The distance of the weft lines from each other varies from 1.6 cm. in the kilt to .59 in the *taniko* borders and there is also variation from wide spacing in the upper part of the garment to closer spacing in the lower part. When feathers or tags were attached it was necessary to make the garment upside down, so that the suspended tags would not be in the worker's way during the weaving process. Where there were no tags, garments could be made right side up, allowances being made for the attachment of borders, for as the Maori always worked horizontally, it was sometimes necessary to change the position of the garment during its manufacture.

Fig. 16 BAG decorated with feathers.

The weft techniques used were four in number: spaced single pair twining (Fig. 17*a*); close single pair twining (Fig. 17*b*);

two pair interlocking weft (Fig. 17*c*); and wrapped twining used in the *taniko* borders (Fig. 17*d*); *a* was used in kilts, rain capes, and rain cloaks; *b*, in war cloaks to give a close protective fabric, in dogskin cloaks, might be concealed behind the warps or use as the design demanded. A stiffening cor was also used which was carried straigh across and not utilized in the design.

In order to fit his garment to the contou

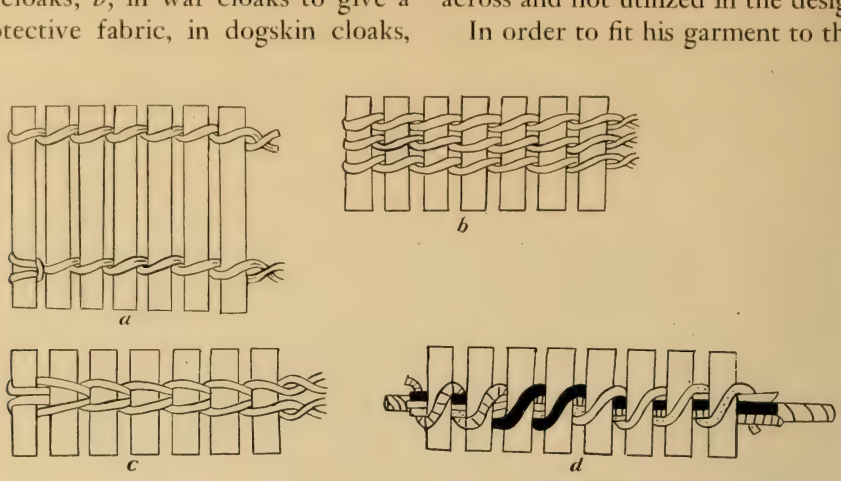

Fig. 17 WEAVING TECHNIQUES. *a*, Spaced single pair twining. *b*, Close single pair twining. *c*, Two pair interlocking weft. *d*, Wrapped twining used in the *taniko* borders. (After Dr. Buck's analysis.)

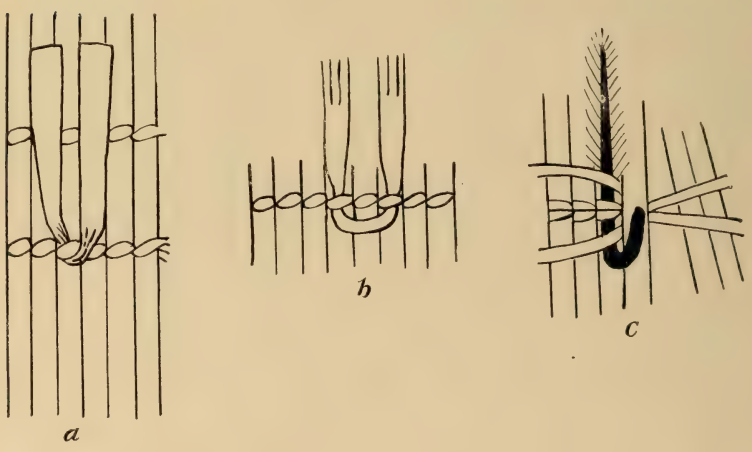

Fig. 18 ATTACHMENT OF TAG MATERIAL. *a*, Simplest form used in rain capes. *b*, Elaborate technique used in finer cloaks. *c*, Attachment of feathers.

and single lines were sometimes used as a variation in spaced single pair twist; *c* is a much improved technique originating in the weft rows used in commencing a garment and employed in all finer work; and *d* was used to give the intricate *taniko* border patterns. In *d* the weft cord was composed of several differently colored strands which

of the body, the Maori developed a tech nique of weaving in either elliptical o wedge-shaped inserts to give the extra widt necessary at shoulder and hip.

The simplest form of attachment of ta material is the rain cape (Fig. 18*a*) with veritable thatching used to turn the rai This was effected by using short war

Fig. 19 CLOAK showing taniko border.

lengths and leaving one end free or by adding extra pieces of material and including them under the weft rows. From this utilitarian garment developed the custom of adding ornamental tags of thick cord, or rolled strips of flax. When tags were used in the finer garments, a new technique, that of placing the middle of the tag piece under the weft row, was used (Fig. 18*b*). When used as ornaments, tags were spaced farther apart and became purely decorative, taking various forms: loops, spirals, circles, ovals, twists.

when they were dyed, only the fibrous part turned black: capes *mai*, *pokeka*, or *pora* short mantles which only covered on shoulder and reached to the waist, and mad of *kiekie* or *toi* as well as flax—occasionall rolled strips like those in the kilts were used and cloaks (Fig. 19), upon which the whol range of Maori technique of weaving an ornamenting was expended.

The student of art will be mainly in terested in the *taniko* (Fig. 20) pattern borders woven in several colors with th

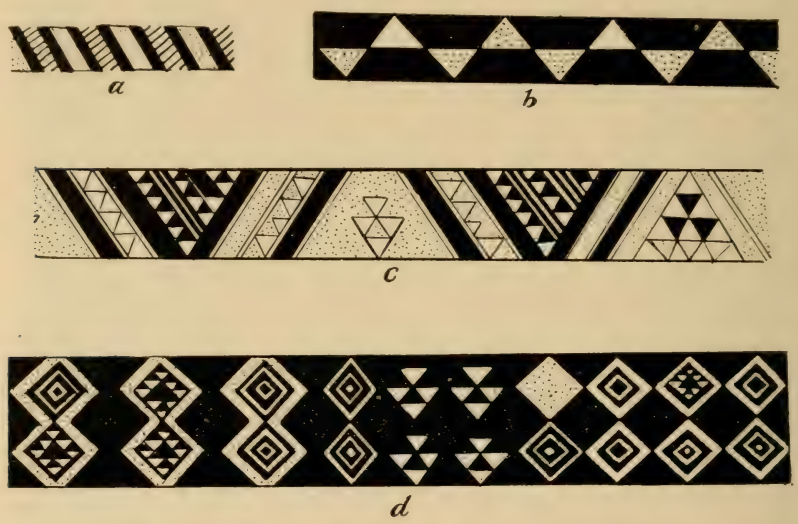

Fig. 20 TANIKO DESIGNS

When feathers were used, the same technique was employed in fastening them (Fig. 18*c*), the feather being fastened vertically with the tip upward and the bent quill end caught twice in the weft. Tassels for a very much valued type of cloak were made of dogs' hair and strips of dog skin were also used for ornament.

The types of Maori clothing can be divided into: the *maro* or small triangle-shaped apron, the simpler ones made of flax fiber or sedge, the more elaborate ornamented with various types of tags; the *piupiu*, kilts or short skirts falling from waist to knees, made of strips of flax scraped at intervals, so that

elaborate combination of triangles an lozenges. The Maori also wove coarse floo and bed mats of undressed flax and mad many types of bags of which there are severa good examples in the collection.

While the bulk of the weaving was don by the women, parts of the fine cloaks an especially the *taniko* borders were done b the men. It was to a girl, however, that ceremonial initiation into the art of weavin was given. A priest, who was a master o both ritual and technique and the youn girl, went alone together into the *whare pora* weaving house. Over a bunch of flax whic she held in her hand the priest recited a

incantation to make her holy enough to handle the sacred thread and before fastening it across the weaving frame she had to bite the sacred right-hand stick. She then began to weave, copying some old and beautiful garment spread on the ground before her, while the priest chanted an invocation to make her learn quickly and well. Until her initiation was finished, she was not allowed to eat, to approach cooked food, or communicate with anyone. Her first web was never finished but left as a "pattern piece"; before she could finally leave the weaving house the priest prepared a ceremonial meal which novice and teacher ate together, thus removing her sacredness and freeing her to weave in safety all the rest of her life.

Tattooing

LIKE MOST of the Polynesian peoples, the Maori practised tattooing and brought the art to a higher degree of perfection than any other Polynesians, except possibly the Marquesans. The Museum is fortunate in having the magnificent Robley Collection of preserved Maori heads, the finest collection of such heads in the world.

The Maori preserved the heads of their chiefs and also of beloved wives or favorite children, and the heads of their enemies. Of their enemies, only the head of a chief, and beautifully tattooed heads of other warriors were preserved. An untattooed man was left where he fell. During a war these captured heads were exhibited and paraded as encouragement to the warriors, and as a goad to further ferocity. An important element of a peace treaty was the exchange of the heads which had been carefully embalmed during the war. Should a chief destroy the head of an enemy chief it was a sign that peace would never be concluded. Thus the preservation of heads played a double role; it kept alive the memory of the dead, and at the same time preserved the work of the artists in tattoo, of whose skill, expended on perishable human flesh, we have such scanty records in the other islands. In later times, pieces of handsomely decorated thigh skin, such as the piece exhibited, were stripped off and used to cover cartouche boxes.

To preserve the heads, the Maori took out the brain and all the fleshy matter inside the skull, stuffing the cavities with flax. The head was wrapped in leaves and steamed and then exposed to the smoke of a wood fire impregnating the skin with pyroligneous acid which acted as a preservative. All flesh was removed and flax or bark used as packing to restore the face to its original contours. The nose cavity was stuffed with fern root and the lips sewn together, or left so as to show the teeth. The skin at the bottom of the skull was drawn together, leaving an opening about the size of the hand.

There were two types of tattooing in New Zealand, the elaborate curvilinear patterns of the northern Maori and the simple straight line tattooing of the southern Maori. Two kinds of instruments were used in the northern group, one a small, toothed, bone adze similar to that used throughout the Polynesian area, the other a sharp single-pointed instrument, used in making the singular deep furrows characteristic of the northern group. The blade of the instrument was made of bone and attached to a wooden handle which contained a forefinger rest and was sometimes decorated. The single-pointed *moko* was like a chisel with a whalebone blade. One end of this instrument was shaped like a flat knife to wipe off the blood. Pigment was made by burning several kinds of wood, or sometimes the vegetable caterpillar, in a small kiln. The soot was collected on a frame of flat sticks and was mixed with dog fat. It was either used in this form or else fed to a dog and the kneaded fæces used.

Fig. 21 TATTOOED HUMAN HEADS from the Robley Collection in the American Museum of Natural History. CARVED DRINKING TUBE, (Third from left, bottom row).

The pigment from the burnt *kauri* gum was sometimes collected on a basket smeared with fat, and kept thus for generations. The pattern was usually sketched on with a mixture of charcoal and water, or with a sharp point. The instrument was either dipped in the pigment or the operator held a little of the pigment between the thumb and forefinger and drew the chisel through it. The blood was wiped away with a piece of flax, a wooden spatula, or the end of the instrument.

the one exhibited in the case of Maori heads, shown in Fig. 21. At the conclusion of the operation, three ovens were lighted, one for the artificers, one for the gods, one for the newly tattooed and the rest of the people. The priest, by a ceremony of cooking food which was then ceremonially eaten, freed the people from the taboo. A human victim, to obtain which a war party was dispatched, was sacrificed when a chief's daughter had her lips tattooed. Contrary to the usual Polynesian practice, tattooing was done, not at

a *b*

Fig. 22 TATTOOING DESIGNS. *a*, A forehead design. *b*, A cheek design.

Men were tattooed on the face, the upper part of the trunk, and the thigh to the knee. Women were tattooed on the lips, between breast and navel, on the thigh, and on the hands and arms; but more usually they had only a compact design on the lips and chin.

The professional tattooers were well-paid itinerant individuals. Slaves who knew the art were immediately freed.

The religious aspect was particularly emphasized by the stringent taboos. During the process the whole village was taboo, and the patients were not allowed to feed themselves with their own hands. To meet the requirements of this taboo, feeding funnels were made and were often elaborately carved like

puberty, but after full growth was attained. Women were always tattooed on the lips before marriage. Definite tattoo marks were not used as badges of mourning, but the ceremonial cuts women made on their bodies were filled in with pigment. Heads of dead relatives were sometimes tattooed.

Tattooing was more definitely associated with war than with rank. Slaves taken in childhood were not tattooed and there were particular patterns which a slave could not wear. But many chiefs were not tattooed at all and priests had only a small blotch over one eye. New tattoo marks were sometimes assumed by all the warriors of the tribe before going to war.

The designs used by the southern tribes appear to have been simple series of parallel lines, arranged in groups of three or four, alternately vertical and horizontal. The only

the chin, the cheek (Fig. 22), etc. The thigh pattern (Fig. 23) and the scroll used on each buttock were invariable; but the smaller units used on the face permitted great in-

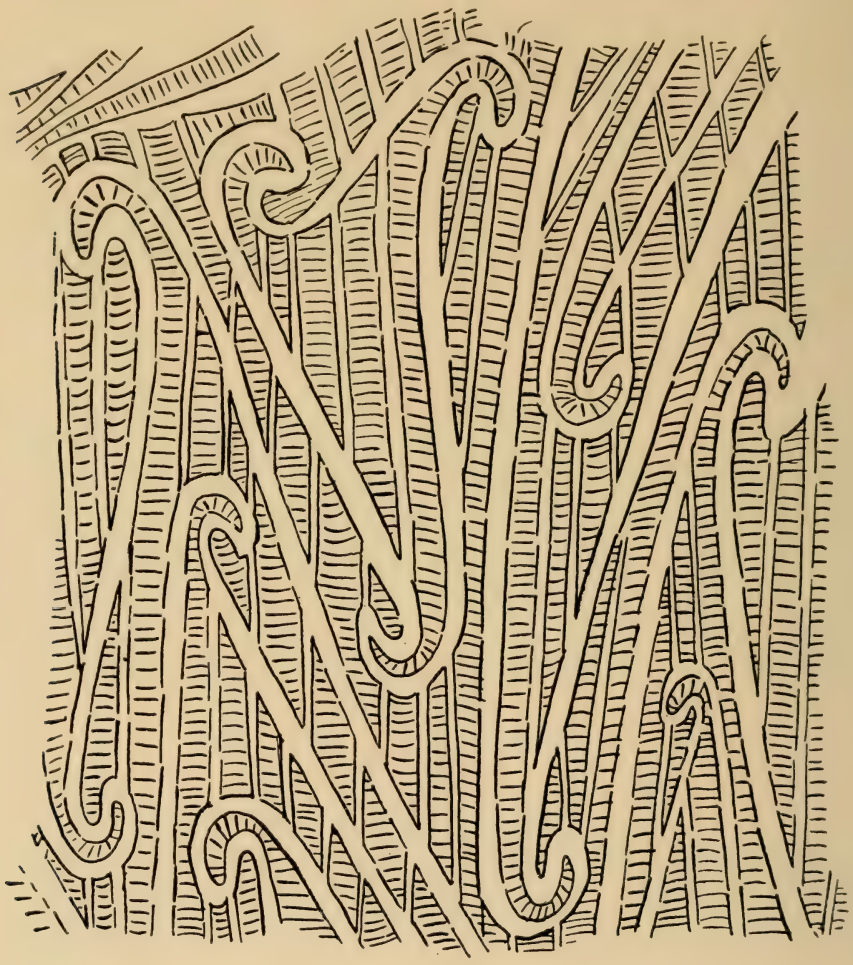

Fig. 23 TATTOOING DESIGN ON THIGH

curvilinear element was an S-like figure in the middle of the forehead. The designs used by the northern tribes were all curvilinear and elaborately stylized in respect to the sex of the wearer and the part of the body to be decorated. Great emphasis was placed on the conformance of the design to the shape of

dividuality of arrangement, although all o these were based on a few curvilinear motifs It is possible to analyze the designs into sever motifs: (1) lines of dots or strokes, (2) ma or plait work, (3) a ladder motif, (4) chev ron patterns, (5) a circinate scroll, (6) a anchor outline, and (7) trilateral scroll.

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A DRAMA OF THE MICROSCOPE

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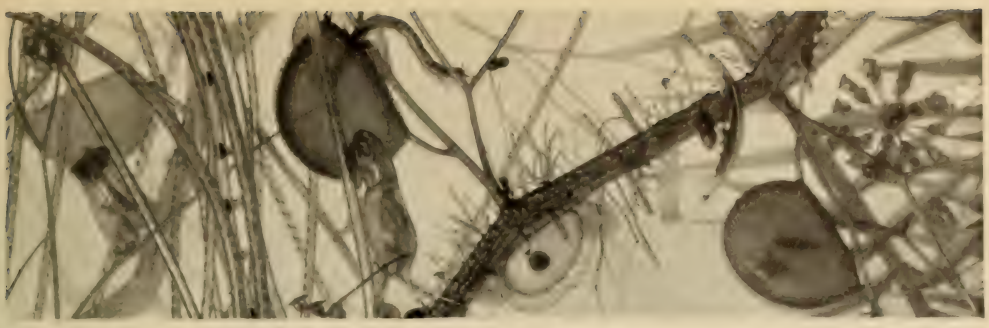
AN ENCHANTED FOREST OF THE MICROSCOPIC WORLD

A detail of the new Rotifer Group in the Darwin Hall of the American Museum, constructed entirely of glass, and faithfully portraying many of the strange plants and animals that normally might be found in one half inch of pond bottom, magnified to more than four feet in diameter



A DRAMA OF THE MICROSCOPE

The Microscopic Life Found in One-Half Inch Pond-Bottom Magnified One Hundred Diameters or, Cubically, One Million Times

By ROY WALDO MINER

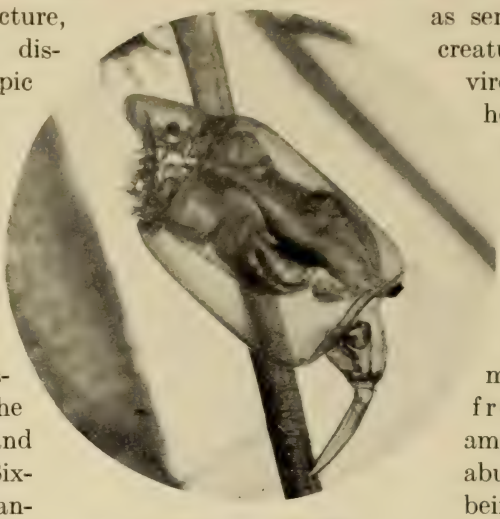
Curator of Lower Invertebrates, American Museum

The new Rotifer Group in the Darwin Hall of the American Museum was designed and directed by Doctor Miner. The field work on which it is based was largely carried on at Mt. Desert Island, Maine, by Doctor Miner in collaboration with Mr. Frank J. Myers, whose intimate knowledge of rotifer anatomy, natural history, collecting methods, and microscopic technique were of inestimable value during the preparation of the group. The field color sketches were prepared by Dr. George H. Childs, under Doctor Miner's direction. The remarkable glass modeling which is the outstanding feature of the exhibit is the work of Herman O. Mueller, of Doctor Miner's staff of artists, and sets a new mark in work of this kind, both as an achievement in skillful preparation of the hundreds of component models, and in the successful assembling into one complex whole of a multitude of fragile parts. The delicate coloring of the models and background is the work of Mr. W. H. Southwick, while those features of the pond bottom constructed in wax were modeled by Mr. Chris E. Olsen.—THE EDITORS.

MORE than three centuries have passed since Zacharias Jansen of Middelburg, in the Netherlands, and his fellow townsman, Johannes Lippershey, produced two little instruments destined to have most far-reaching effects upon human knowledge. Both were contrivances in which crude glass lenses played a most important part. Jansen's invention was the first microscope, and was in use by 1590. Lippershey's was the telescope, which was sold by him in 1609. The following year, Galileo, in Italy, had heard of Lippershey's invention and spent a night considering the optical principles involved. By the next morning, he had reinvented the instrument for himself, and, a little later, adapted it for examining minute objects. Jansen and Lippershey were merely ingenious opticians. Galileo's adaptation of the telescope to astronomical purposes and the remarkable discoveries he made with it have coupled the instrument inseparably with his name, so that he is commonly credited with its invention, and, according to an enthusiastic biographer, with that of the microscope, as well. While all credit is due, therefore, to the two Dutch opticians for originating the telescope and the microscope, it was the genius of Galileo that perceived the significance of the former instrument and by its aid he overthrew for all time the ancient Ptolemaic cosmogony, assiduously fostered by the ecclesiastics of the day, and demonstrated the truth of the essentials of the Copernician theory. From that time on, to all intelligent men, the earth moved around the sun. The world now knew that Jupiter had satellites, that the strange planet, Saturn, existed, that there were spots upn the face of the sun, the observation of which proved its rotation.

While the microscope was not at first used for the study of natural history, by the middle of the Seventeenth Century, a group of keen observers, including Hooke and Grew in England, Malpighi in Italy, and Swammerdam and Leeuwenhoek in Holland, turned its magnifying power upon hitherto invisible details of animal and plant structure, and the last-named discovered the microscopic world of life.

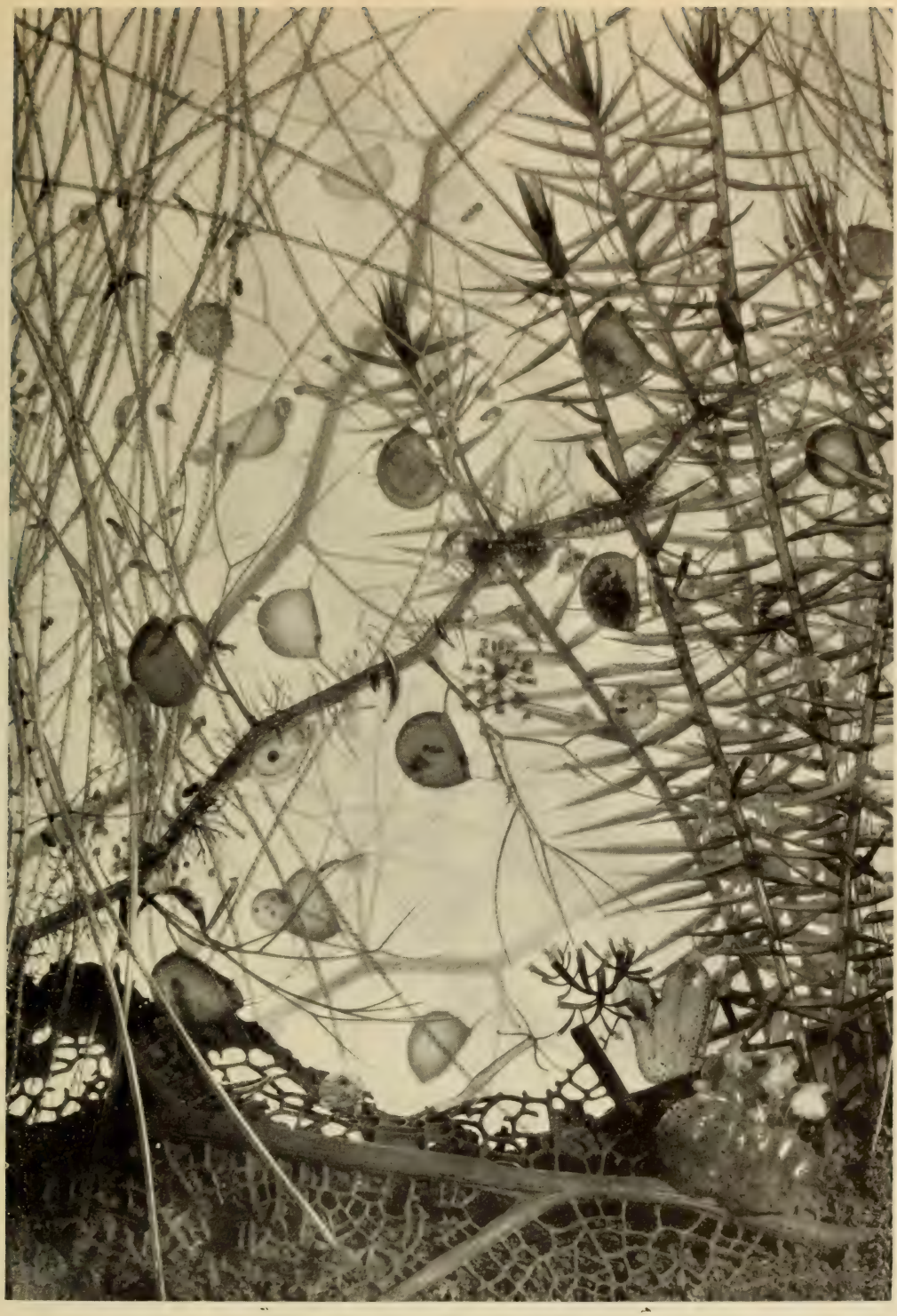
Men had formerly lived in a world bounded by the limits of their unaided eyesight. That which existed beyond was the subject of more or less fantastic surmise. While the mathematicians and astronomers of the Sixteenth Century dimly anticipated something of the truths of the universe outside the range of their visual apparatus, the invention of the telescope and the microscope suddenly furnished glass windows to the practically flat and two-dimensioned room in which mankind had hitherto dwelt. Through the one they now gaze up into the starry heavens to see the planets swinging on their appointed courses around the sun. They penetrate interstellar space and comprehend that the twinkling stars are immense suns of other systems, that outside our universe are other unbelievably distant universes dimly shadowed like luminous cloud patches. Through the other window, the microscope, they gaze down into their own world of life, so enlarged by the magic of refracted light rays, that even the minute cells of animal and plant tissues are disclosed to view, as the fundamental units of living structure. In a drop of pond water, Leeuwenhoek saw myriads of minute living creatures, the existence of which was hitherto unsuspected, because invisible to man's naturally coarse vision. These living beings crowd their watery habitat, hurrying hither and thither on the business of life, as seriously intent as the creatures of our larger environment. Leeuwenhoek thus became the pioneer adventurer in this new world, which interpenetrates our own so intimately, and yet, through the accident of size, is so immeasurably separated from us. He was amazed at the variety and abundance of these tiny beings and his writings betray his confusion of mind. His letters, published from 1673 to his death in 1723, largely written to the Royal Society of London, were filled with accurate but yet miscellaneous descriptions of his observations. They were accompanied by a wealth of drawings, remarkably faithful, considering the time in which he lived and the crudity of his instruments. For his microscopes were mostly simple magnifiers, which he ground and mounted himself. He possessed 247 of these, containing 419 lenses, which apparently gave him magnifications of from 40 to more than 270 diameters. They must have been of fine quality, for the most part, judging from his results.



A SAVAGE ROTIFER

Dicranophorus crouching to spring upon its prey. Lightly balanced on its pointed toes, with body contracted, it awaits an unwary victim

Among the most conspicuous of the microscopic creatures that attracted Leeuwenhoek's attention were the animals since known as rotifers, of which he pub-



A ROTIFER JUNGLE SEEN THROUGH A MICROSCOPE

The new Rotifer Group in Darwin Hall of the American Museum, exquisitely modeled in glass, represents a cubic half inch of pond bottom magnified one hundred diameters, or, cubically, one million times. A spray of the carnivorous water plant *Utricularia vulgaris* spreads its bladder-shaped animal traps diagonally across the field of view, to snare the microscopic rotifers and other tiny creatures which make up its food

lished descriptions in 1703. A contemporary investigator, the Rev. John Harris, antedated him by seven years in making the first published, but rather vague, description of an undoubted rotifer. Thus, these remarkable inhabitants of the minute world, first recorded in 1696, have been known to microscopists for 230 years. Yet it is quite likely that by far the greater majority of educated persons today have never heard of them, and at the first mention of their name, would immediately ask "What is a rotifer anyhow?

A ROTIFER CLIMBING UP A PLANT STEM
With swimming discs folded in and concealed, *Rotaria macrura* hunts for small organisms along a *Spirogyra* stem, advancing like an "inch worm" by alternately arching and extending its body

The new exhibit in the Darwin Hall of the American Museum is intended to answer this question. Rotifers are unknown, simply because of their small size. The new Rotifer Group enlarges a cubic half-inch of their watery habitat, to one hundred diameters, or, cubically, one million times, so that it occupies a space measuring fifty inches, or more than four feet across. The front of the exhibit is constructed to represent a huge magnifying glass, through which the visitor peers into a jungle of water plants peopled by hundreds of tiny animal forms. In their natural size, these plants would cross and recross an area about the size of one's thumb-nail. Here, they are so greatly enlarged that they appear to tower above the observer's head, and their great size gives them a strange and unfamiliar appearance. These and all the other remarkable and complex features of this group have been skillfully modeled in glass to represent the life of a minute area exactly as it appears through a microscope. To the right, a cluster of water thyme (*Philotria canadensis*) rises with slender, pointed leaves and graceful translucent green stems. To the left, and arching also over from the right, criss-cross tangles of *Spirogyra* interweave their slender, tubular strands. When seen in natural size, this plant appears to consist of close tangles of slender silken threads of green, which gather in great masses in still water, and is familiar to us all under the name of "pond scum." It is supposed by many people to render the water noxious. The opposite, however, is true, as the green color of the scum is due to the abundant chlorophyll, which, under the action of sunlight, breaks up the harmful carbon dioxide gas of stagnant waters, utilizing the carbon for food, and releases free oxygen, thus rendering the water purer. In the magnified representation of *Spirogyra*, shown in the group, the strands are seen to be formed of cylindrical cells set end to end, and the green chlorophyll is gathered into spiral bundles (chromatophores), giving the strands of the plant a spirally striped appearance. Hence, the name, *Spirogyra*, is quite appropriate. When two strands of *Spiro-*

FLOWER-LIKE ROTIFERS SETTLED IN A NOOK AMONG THE WATER PLANTS

A colony of tube-building rotifers (*Floscularia ringens*) has built a branching cluster of trumpet-shaped "houses" on the edge of a dead, skeletonized leaf. In the center is the transparent, double dwelling of a pair of graceful, comb-armed rotifers (*Stephanoceros fimbriatus*), which are really ingeniously contrived animal traps of voracious habit. In the foreground, the large and unusually beautiful *Octotrocha speciosa* peer out of their jelly-like habitation

gyra come in contact, the cells which chance to be closest send out hollow projections to fuse with those of the opposite strand and connect the cells in pairs. The chromatophore of one cell of a pair thus united, then passes out of it through the connecting canal into the other cell and unites with the substance of its chromatophore, forming an oval body, which, after union of the cell nuclei, becomes a spore. This is released into the water and eventually starts the growth of a new plant.

Diagonally across the center of the group is seen the most remarkable plant of all. This is the bladderwort, *Utricularia vulgaris*. Its stem is slightly zigzag,and, through its translucent walls may be seen the green vascular bundles of the internal structure. Along the stem, at intervals, are slender, branching, spine-like leaves, which, in real life, are very delicate and flexible. From the stem of each of these grows a curious bladder, also called a utricle. These bladders give the name, bladderwort, to the species. From the word, utricle, is derived the scientific name, *Utricularia*. These utricles are actually animal traps. They are about the size of a pin-head, but are shown here, modelled in glass, about three or four inches in diameter. The tiny animals, with which our microscopic world is swarming, are captured by these traps and, as they die and decay, are absorbed by the plant cells for food.

THE TIGER SPRINGS

The *Dicranophorus* darts upon its victim with open, pincer-like jaws (seen at the right), and relaxed and now slender body. This is the same species of rotifer as the one shown on page 4

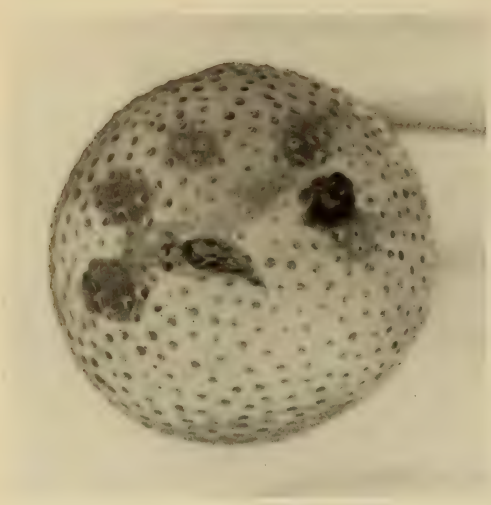
This reminds us of the terrestrial pitcher plants, which capture and digest insects on land. Growing upon the main stem of the bladderwort, we see hosts of minute plants, the unicellular algæ. These are of many varied species, and are so crowded together that they appear like a fine green or brown fluff when seen by the naked eye.

We have examined the vegetation of our microscopic jungle. Let us now become acquainted with its inhabitants, the minute creatures that swim or prowl through its tangled growths or build crystal palaces, in which they dwell upon its branches.

As above mentioned, the most conspicuous of these are the rotifers. The typical rotifer is a somewhat top-shaped animal, that is to say, its body tapers from a relatively large, often flattened head, to a more or less pointed foot, usually furnished with two, likewise pointed, "toes." An excellent description with illustrations was given in a recent number of NATURAL HISTORY by Frank J. Myers, in an article entitled "What is a Rotifer?" (May-June, 1925, page 211.) The head has a crown of cilia, i.e., minute moving hair-like structures. The arrangement of this "corona" varies in different species. In some cases, as in the common rotifer (*Rotaria macrura*), these cilia are arranged in a double row around two circular discs, which are literally borne on the shoulders of the animal, just back of the

A WATER PLANT THAT TRAPS AND DEVOURS MICROSCOPIC ANIMALS

A detail of the Rotifer Group showing a single "utricle" of the bladderwort (*Utricularia vulgaris*). This, in the living plant, is about the size of the head of a pin. The trap-door is seen at its lower right margin and a captured rotifer is visible within. A spherical, floating colony of rotifers which cling together by their toes (*Conochilus hippocrepis*) is seen at the right. The stem of the bladderwort is covered with tiny fresh-water algæ, and a crescent-shaped desmid (*Closterium*) shows at the left



A ROTIFER WHICH LIVES INSIDE A COLONY OF PROTOZOA

The spherical colony of the protozoan, *Volvox*, is penetrated by the rotifer *Ascomorpha*, which thereafter lives and feeds inside

mouth-opening and on either side. The cilia lash the water, not indiscriminately, but one after the other in ordered succession. This vibrating movement is so rapid that a wave of motion passes around the discs, giving the appearance of a rotating wheel. Some of the early observers supposed that this was actually the case, and so gave the name rotifers or "wheel bearers" to the animals. They thought that, at last, the principle of the wheel had been discovered in nature, but, with closer observation, it was soon found that this was an optical illusion, and that man still preserves intact as his own invention one of the few mechanical principles not anticipated by nature, namely, that of the wheel rotating upon an independent axis. The rotifer's vibrating coronal circlet of cilia creates a whirlpool in the water, which gathers in still more minute animals, diatoms, and other microscopic particles to be swept down into the vortex where the wide-open mouth is situated. The food stream then passes into a capacious pharynx, to be seized upon by a curious apparatus, peculiar to rotifers, known as the mastax. This is really a set of jaws located in the throat, which differ characteristically in the various species, so that they are used by students of rotifers as a means of identification. In many species, they take the form of toothed forceps that tear the food apart. In others, they act as a grinding mill, and, in still others, as a suction pump. Rotifers of the first sort are active and sometimes prey upon animals of their size or larger. In this case, the rotifer springs upon its prey, suddenly shooting out nipper-like jaws until they project from its mouth, thus enabling it to seize the captive. An example of this is *Dicranophorus forcipatus* (shown on page 8). The second kind, like *Rotaria macrura*, described above, feeds upon very small forms, while those that have suction jaws are herbivorous, feeding upon the contents of plant-cells. For example, *Monommata longiseta* crawls up the filament of *Spirogyra*, cutting a neat round hole in each cell with the tips of its jaws. Then it uses its pumping apparatus to empty by suction the entire

A ROTIFER WITH STRANGE SWIMMING ORGANS

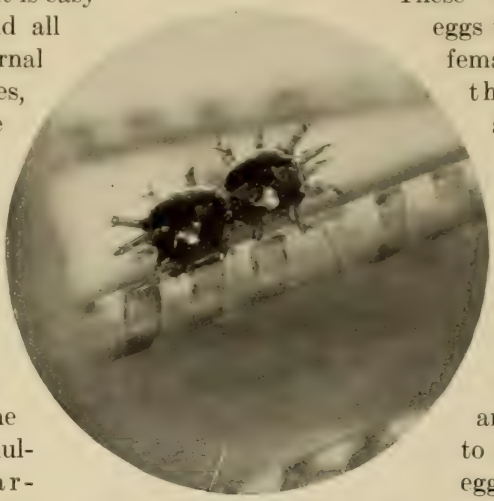
Notommata copeus extends earlike flaps from its head to use in swimming. They are fringed with moving hairs which draw the animal through the water

A PROTOZOAN COLONY OF BELL-ANIMALCULES (*VORTICELLA CAMPANULA*)

Each individual is anchored by a delicate thread of protoplasm which contracts spirally when the owner is disturbed. Highly magnified strands of pond scum (*Spirogyra*) are conspicuous, spiral chlorophyll structures showing through the transparent, tubular walls. Two strands are forming spores, being connected by ladder-like rungs in the process

plant cell of its endochrome. It then proceeds to the next cell to repeat the process.

After passing the mastax, the food reaches the large stomach, which is the most conspicuous organ in the rotifer's body. In the group, it is easy to see this organ and all the rest of the internal anatomy of each species, as the animals are clearly transparent. The stomach has a comparatively thick wall composed of a limited number of large cells which are clearly visible in the larger species and give the organ a somewhat mulberry-like appearance. Here, the food is digested, the residue passing out through the short and straight intestine. One urn-shaped species (*Asplanchnopus multiceps*) has a well-developed mouth and pharynx, as well as a large stomach, but there is no intestine present, the indigestible residue of the food being regurgitated through the mouth.



A MICROSCOPIC WATER PLANT *Xanthidium armatum* is composed of two connected cells armed with spines, which enable it to cling to plant stems

All female rotifers have an ovary situated in front of the base of the stomach. When the eggs are developing, this organ may be so distended as practically to fill the body cavity. The eggs are laid in the water in most cases. Certain species, however, hatch them in the body cavity, the young remaining for a time within the mother's body. Males are very few, compared with the number of females, and are of much smaller size. They have a reproductive apparatus, but no mouth or stomach. They are therefore merely sexual machines which swim about for a few hours before perishing. During their brief career, some of them justify their existence by pairing with the females. The rest just die. The fertilized eggs last over the winter and hatch out the following spring to give rise to females. These produce unfertilized eggs which also hatch out females. Thus, during the summer, brood after brood of females are produced, until cold weather sets in during the fall, when male-producing eggs of smaller size are hatched out, making it possible for another sexual mating to give rise to winter eggs, as before.

Rotifers have a nerve ganglion, or "brain," in the head region, in close connection with which one or more red eyespots occur. A system of nerves connects the brain with various parts of the body. They also have paired "kidneys" and a simple muscular system. In short, they are remarkably complex creatures for their small size, and are in sharp contrast to the single-celled protozoa, associated with them in their microscopic environment, which, in some cases exceed them in size.

Thirty-one species of rotifers are shown in the group. This is not unusual in a normal prosperous community found within a cubic half-inch of pond-bottom, under the environmental circumstances represented in the Rotifer Group. A few of the more interesting species will be mentioned.

One of the largest of the rotifers may be seen crawling up a *Spirogyra* filament toward the left of the group. This is

A VISTA THROUGH A TANGLE OF POND SCUM (*SPIROGYRA*)

The spiral chlorophyll of *Spirogyra* is clearly visible. A large rotifer (*Notommata copeus*) is crawling up a strand, systematically perforating it, cell by cell, to pump out the chlorophyll for food. A utricle of the bladderwort is capturing a harlequin fly larva, which is struggling to escape. At the lower left an urn rotifer (*Asplanchnopus multiceps*) is seen, with its internal structure showing plainly through its transparent body

Notommata copeus. It has the habit of perforating the *Spirogyra* cells and pumping out the endochrome, like *Monommata longiseta*, mentioned above.

At about the center of the group, another *Notommata copeus* is seen swimming. It has a pair of "ear-lappets" extending on either side of its head. These are covered with moving cilia, the rhythmic vibrations of which propel the animal through the water. When it settles on a plant stem to feed, the lappets are drawn in. Just below it is a spherical colony of beautiful rotifers (*Conochilus hippocrepis*) consisting of about twenty-five individuals clinging together by their toes, while the combined motion of their wreaths of cilia causes the whole colony to rotate through the water. Close below the latter, a savage *Dicranophorus* is crouched with its toes resting against a branch of the bladderwort, in readiness to spring upon the next unwary creature that swims by. The utricle near it has apparently forestalled the *Dicranophorus*, for, through the bladder wall, a captured rotifer is dimly seen, vainly trying to find a way out.

Farther down the spray of the bladderwort, an insect larva (that of the harlequin fly, *Chironomus plumosus*) has just been caught by a utricle, and is struggling to escape. The more it struggles, the farther in it goes, for the utricle is lined with glandular hairs pointing inward. Thus, only the muscle contractions in an inward direction are effective. Soon the creature will slip wholly within, and will coil up like its fellow in the bladder farther up the stem, finally to be absorbed by this strange carnivorous plant. How is it possible for a utricle to induce a rotifer or other unsuspecting water animal to come and be caught? By looking at the utricle depicted on page 9, it will be seen that there is a trap-door on the lower free corner of the bladder, from the edge of which project long, branched spines. Rotifers and other small creatures delight to browse among these spines, for small forms of life often adhere to them. In the course of their feeding, they may chance to come in contact with the trap-door. The shorter spines on the upper edge of the door hinder them from easily moving away, and meanwhile the slippery, glandular hairs which cover the surface of the trap cause the victim to slide toward the depression at the upper edge. Here the trap-door is very thin and flexible with a free edge gently held under a curving lip forming that part of the door-frame. As soon as the creature touches this flexible edge, it suddenly gives way and the unhappy explorer drops through the crevice, which immediately closes. The bladder does not digest the rotifer, for no digestive ferment is secreted, as in the case of terrestrial pitcher plants. The animal gradually dies, the fluid products of decay being absorbed by the cell-lining of the utricle, as food for the plant. Water-fleas and protozoa are also captured in this way.

Various species of protozoa are shown in the group. Down at the left, clinging to the base of the bladderwort stem, is a colony of beautiful bell-animalcules (*Vorticella campanula*). These are animals consisting of a single cell each. Superficially they remind one of rotifers, for the bell-shaped body is crowned by a circlet of cilia, but the internal organization is that of a protozoan, with a nucleus and contractile vacuoles. Each individual is anchored to the plant by means of a long, slender filament of protoplasm, containing a contractile thread of denser protoplasm. If the animal is touched or otherwise disturbed, the thread contracts, drawing the stem suddenly down to a close spiral, while the bell-shaped body and its ciliated disc contract into a ball. Soon the thread relaxes and the stem slowly lengthens, while the ciliated bell gradually expands and starts beating the water as merrily as ever.

A TUBE-BUILDING ROTIFER BUILDS ITS CHIMNEY-LIKE DWELLING

Floscularia ringens extends its pansy-like head from the top of its tube and models tiny, spherical bricks of brown mucus with the aid of the finger-shaped projection just back of its head. When finished, these are neatly cemented to the tube margin. The rotifer's home is thus built up like a tiny chimney of the most delicate masonry, resembling fine mosaic

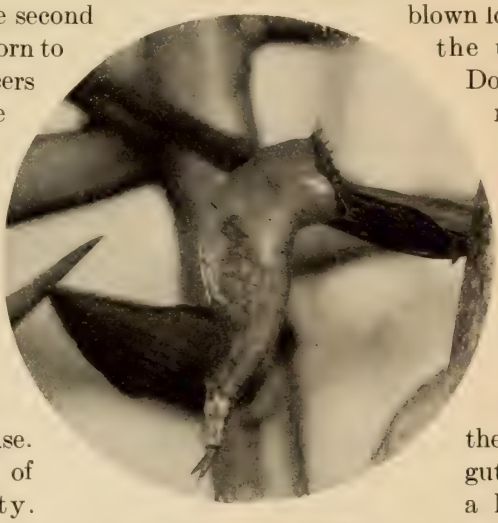
A little to the right of the center is a floating transparent ball, covered with hundreds of tiny green dots, enclosing a number of small dark green spheres. This is a protozoan colony (*Volvox*), often found in fresh water during the spring. The living colony is about half the size of a pin-head, and is very beautiful as it rotates slowly through the water. Each green dot is an individual protozoan, while the small green spheres within are developing *Volvox* embryos. Strange to say, a species of rotifer (*Ascomorpha volvocicola*) lives within the colony, and hatches its eggs there. The young grow and feed within the colony, possibly on the developing *Volvox* embryos, eventually making their escape, only to bore their way into other colonies of *Volvox*.

Perhaps the most beautiful of the rotifers are the flower-like stationary species. A good example is the tube-building rotifer, *Floscularia ringens*. The ciliary wreath of this fairy-like creature extends its petal-shaped lobes, causing it somewhat to resemble a pansy, around the rim of which the extremely delicate cilia vibrate in succession, like a transparent halo of motion. This animal builds a trumpet-shaped chimney to dwell in of tiny spherical bricks of brown mucus, secreted from glands of its body. It spins them into balls one at a time, by means of a hairy, spinning-projection upon its shoulder, and then, with a bob of its head, adds them to the upper rim of the chimney, which thus grows higher and higher. When the young are hatched, they make

their way out of the tube, and settle down on the outside of the parental mansion, to construct their own homes as additions to it. Soon, quite a branching cluster of these chimneys will be built up. Such a cluster may be seen on the edge of the dead leaf at the bottom of the group.

In the lower right-hand corner, near the branching chimneys of *Floscularia*, are magnificent clusters of two other stationary species. One of these, *Stephanoceros fimbriatus*, has built a double chimney of transparent gelatinous material, and shows one individual retired into its house, while the other extends its graceful head with five curving, fern-like arms out into the water. Fairy-like as this creature may appear, it is a most insatiable animal-trap, for its arms form a net to entangle swimming rotifers or protozoa. These settle down into a funnel-shaped vestibule from the bottom of which a hollow whip extends into a second chamber below. When the victims in the funnel touch the base of the whip, they are suddenly *snapped through its hollow lash* into the second room. Here they are torn to pieces by toothed pincers and conveyed to the stomach. So the fairy, after all, is a most voracious Gorgon!

In front of this creature, may be seen a colony of flower-like rotifers, living clustered in a roomy gelatinous house. This is a species of remarkable beauty. Its scientific name is *Octotrocha speciosa*. It was first discovered in China. Then some years ago, it was found in a pond on Long Island. Later on, Frank J. Myers discovered it abundantly in southern New Jersey, and, within the last few years, both Mr. Myers and the writer found it in ponds on Mount Desert Island. For the most part, it occurs in association with dead oak leaves, but, in the latter locality, it was abundant on the water-plant, *Nitella*. How could such a species be of such sporadic and yet wide-spread occurrence? The most probable answer is doubtless the clue to the wide distribution of many rotifers. When pools, in which rotifers occur, dry up, the animals may die or, in case of many individuals, they may go into what is known as "resting stage." The rotifer telescopes into a contracted condition, and stops, with plugs of hardened mucus, any openings through which its small modicum of moisture might evaporate. In such a state, it will resist drying up. Yet, being of the size of a mote, it is easily caught by wind currents and blown long distances through the upper atmosphere. Doubtless, millions of rotifers, as well as their winter eggs, are sown all over the world by the winds, and, when dropped in favorable localities, they dissolve out, come to life, and prosper once more. It is a fact that the dust from a dry rain gutter, on the eaves of a house, will be found prolific in bdelloid rotifers, when placed in a dish of water.



A TYPICAL ROTIFER

Cyrtonia tuba is a top-shaped creature crowned with a wheel-like wreath of cilia

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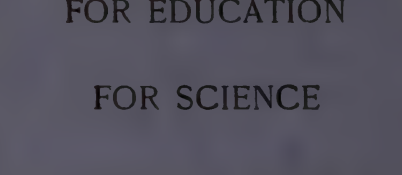

FOR THE PEOPLE

FOR EDUCATION

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POTTERY OF THE SOUTHWESTERN INDIANS

BY PLINY EARLE GODDARD

GUIDE LEAFLET SERIES, No. 73

THE AMERICAN MUSEUM OF NATURAL HISTORY

NEW YORK, N. Y.

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INTRODUCTION

The pottery of America differs in two important respects from that of the Old World. For several thousand years the potter's wheel has been used in the Old World and the ware has been covered with a vitreous glaze. In America the potter's wheel was unknown in pre-Columbian times; glaze was sparingly used and not over the entire surface of the vessel. When the potter's wheel is employed the centrifugal force produced by its rapid revolving throws the paste outward against the bare hand or some implement and the vessel of necessity takes on a circular shape. The vertical outline is controlled by moving the resisting hand in toward the center or away from it as may be desired. In America, where the Indians do not use the wheel, vessels are sometimes shaped in a mould or modeled free-hand. Usually, however, they are built up by applying cylinders or ropes of clay, round by round, or in a long spiral. These successive rounds of clay are made to adhere by pressure exerted with the fingers.

From the Southwest a great abundance of pottery vessels has been secured. Some of these are of recent manufacture, made by the Indians now inhabiting the Pueblo villages. A much greater number has been recovered from the ancient ruined Pueblo buildings and from the nearby burying grounds.

METHODS OF MAKING

The methods employed in making pottery in ancient times can only be surmised, but for the modern peoples we have excellent detailed information. The following account is based upon the work of Dr. Carl Guthe.

The women go to the clay pits from which the material has been secured for generations and bring back a supply in a shawl or some other container which they can carry on their backs. The clay is first very carefully sifted and hand picked to remove all pebbles and other extraneous matter. To the clay is added a considerable amount of tempering material, sand, finely pulverized lava, or ground fragments of discarded pottery. When the materials have been thoroughly mixed, water is added, and the mass kneaded with the hands. The amount of tempering

material is judged by the potter without resorting to measurement. There must be sufficient to prevent the cracking of the vessel when it is sun-dried and not enough to cause the vessel to fall apart.

When the material has been prepared, the vessel is begun by molding the bottom portion with the hands. This is placed on a shallow bowl-like piece of pottery to support the vessel and allow it to be moved about without direct handling. To this molded bottom is applied round after round of the paste rolled into cylinders or ropes. It is usually necessary to allow the material to dry after the addition of each three or four rounds of the moist clay. While one vessel is drying another may be worked upon. The vessel is given its approximate final shape as it is built up, but the modeling is completed by rubbing the inside with a piece of gourd shell, while the hand is held on the outside of the vessel directly opposite to control the amount of pressure exerted. The exterior of the vessel is also rubbed down and all traces of the method of building up with cylinders of clay are obliterated. The modeled vessel is then set aside to dry either in the sun or in the house oven with a slow fire.

When the vessel is sufficiently hardened by the slow drying it is scraped to produce an even surface and polished or smoothed. The next step is the application of a slip on the surface of the vessel to be decorated. The material employed is a fine clay, either white or red, of which a saturated solution is made in water. This is applied to the vessel with a small mop in five or six coats, each of which is allowed to dry before the next is applied. This slip is polished with a smooth, water worn pebble. The designs are drawn in free-hand with a brush made of a strip of yucca leaf, the end of which is frayed. The paints employed are black or some shade of red. The latter material is a mineral and the color is no doubt due to the presence of some form of iron. Black paint, however, is of vegetable origin. A syrup is made from bee-balm, a thick-stemmed herbaceous plant which is boiled in water for several hours before the syrup is of a sufficiently dense consistency. It is allowed to ripen for several months after being prepared and is then ground in water and applied to the vessel. The black color is no doubt due to the carbonization of this syrup, the fire not being sufficiently hot to consume the carbon.

When a number of vessels are ready for firing the oven is prepared. A fire is built on the ground where the firing is to take place. After the fire has burned down a grate-work is put in place a few inches above the surface of the ground. On this the vessels are arranged, bottom side up, so that they will rest securely. Around these vessels are placed slabs of manure from the corrals. Sheep manure is preferred, horse or cow

manure may be employed. The material must be thoroughly dried so as to burn evenly. Kindlings are placed under the grate and set on fire. The woman watches her ware closely, noting the color, and when that is just right withdraws the fuel, removes the vessels, and places them where they will cool.

METHODS OF ORNAMENTING

The visual effect of a pottery vessel depends first upon its shape and second upon the character and treatment of its surface.

The forms of the vessels in the Southwest vary somewhat with the locality, but a classification into several prevailing types may be useful. The following are usually recognized. Bowls are vessels with wide mouths and sloping sides that are not straight; usually the walls of the bowl flare outward, but in some cases they recurve toward the top, forming a hemisphere or somewhat more than that. Ollas have narrow mouths and curved sides. In some cases vessels are provided with vertical lips for holding covers in place. Cylindrical jars occur with straight or fairly straight walls and therefore with mouths of medium width, the vessels being taller than they are wide. Pitchers have a constricted top and a vertically placed single handle. Ladles and spoons both occur, the former having hemispherical bowls which may have been derived from the use of gourds. Besides these recognized forms, there are many curiously shaped vessels, including human effigies.

The character of the rims of the vessels is frequently employed in the classification of pottery objects, particularly where only sherds are available. In some cases the rims are straight, in others they are curved inward or outward; the edges may be either flat, rounded, or sharp.

The second important feature giving a definite appearance to pottery vessels is the treatment of the surface. This may be merely smoothed down and left plain or it may be ornamented. The ornamentation may be produced by making the surface uneven so as to cause variation in light and shade. This is accomplished by several methods. One of widespread use is to indent the surface of the vessel, while it is still soft, with a pointed instrument, by the application of a carved paddle, or by rolling an incised disk over the surface, transferring the designs on the paddle or disk to the pottery. A second method is the application of pellets or strips of clay to the surface of the vessel, to which they are made to adhere. In the Southwest these methods are but sparingly used. Lastly the surface may be made to produce light and shade by leaving the successive rounds of clay unsmoothed, with the prints of the finger or implement used in pressing the rounds together left in view.

Pottery of this type is called corrugated and is found generally over the Southwest but is not known in other regions of North America.

The surface of vessels may also be decorated by the use of pigments. Ordinarily the vessel is prepared for painting by smoothing the surface and by applying a slip to produce a uniform background of the desired shade. The designs are then painted in free-hand and become permanent after the vessels are fired.

Southwestern pottery should be regarded from two points of view. The first is historical, tracing the development of the art of making and decorating pottery from their beginnings to the present; and second, the local variations of pottery styles both in ancient and modern times.

ORIGIN AND DEVELOPMENT OF POTTERY

The first people known in the Southwest made no pottery. They were highly skilled in textile art, which is shown by the baskets and woven bags found in their graves. Because of this textile skill they are known as Basket Makers. Following them were a people, perhaps the descendants of the Basket Makers, who mixed clay with strands of bark or cornhusks and molded thick-walled vessels. Many of these were molded in baskets, as can be seen from impressions left on their exteriors. These crude vessels were sun-dried but not fired. The firing would have consumed the vegetable binding material. The people who made this unfired pottery have been assigned to the period known as Basket Maker III, in the Southwestern chronological scale. At the close of this period and during the succeeding one (Pueblo I) tempered or true pottery which was properly fired was made.

Up to this time vertical walled stone houses were not built. When these houses were first constructed the units were so small that they accommodated only one or at most a few families. Somewhat late in the pre-Spanish period the people gathered together in large villages, living in great communal houses. These builders of the straight-walled compound houses are known as Pueblo dwellers. From the beginning until the Spanish period they made two prevailing styles of decorated ware, one in which the surface was left uneven or intentionally made so, producing light and shade; and the other decorated with designs painted on a white or red slip.

PREHISTORIC POTTERY

CORRUGATED

Manipulation of the pottery-making technique, in order to produce ornamentation, may be observed in early examples of fired wares (Basket Maker III). By leaving unsmoothed at the rim, the last few coils of clay used in building up the vessels, broad decorative bands with plain

surfaces were produced. Later, the entire outer surface of the vessels was allowed to remain unsmoothed, showing distinctly each round of the spirally applied rope of clay as well as the finger marks where pressure was exerted to make the successive rounds adhere to each other. Decoration was achieved by treating successive rounds differently, producing a banded effect, and by applying the fingers with some regard for spacing, so that designs were produced. Pottery of this sort is known as corrugated. In most localities these coils of clay are of some width, about five or six to the inch. On the headwaters of the Gila River were a people who specialized in corrugated pottery. Some of their wares have twelve coils to the inch. Not only are these coils very fine but very evenly and regularly executed. These unpainted wares were used largely for cooking. Painted decorations on vessels placed over the fire would soon be obscured by the smoke. The surface of sun-dried vessels before they are burned was sometimes highly polished by smoothing with a stone. If the fire was smothered just before the firing of these vessels was completed, the ware came out a lustrous black. The Santa Clara Indians at the present time make use of this process and the interiors of some of the Tularosa prehistoric bowls have such a finish.

PAINTED WARE

Vessels decorated with painted designs are in most cases first given a slip. The surface of the sun-dried vessels is scraped and well smoothed. The slip consists of a solution of clay in water and the color depends upon its composition. White was most commonly employed in prehistoric times, but vessels with a red slip are distributed over the entire Southwest.

The painting on these prehistoric vessels is chiefly in black. The designs fall into two main classes, depending upon whether the lines are straight and form angles; or curved, frequently making spirals. The spaces which compose the designs may be in solid black or in hatch work, the two being often combined on the same vessel for purposes of contrast. With the exception of one region—that of the Mimbres Valley—the decorations are usually not realistic nor the result of conventionalization, but geometric. Pieces with drawings of animals and men, poorly executed and ludicrous in aspect are rarely found in other regions. The designs generally are applied to the vessels in encircling bands but sometimes in panels. The bands may consist of lines of varying width, or of one or more simple motifs repeated many times. In both the angular and curved designs interlocking is frequently employed. Some of the most characteristic design elements are shown in the illustrations.

LOCAL VARIETIES

The following are the main regions in which distinctive pottery types are found:

Mesa Verde in Colorado and northeastern New Mexico; Chaco Cañon, south of the Mesa Verde region; and Kayenta in north central Arizona, are within the drainage of the San Juan River. On the headwaters of the Gila River, chiefly in the drainage of the San Francisco River, one of its main tributaries, a very special style of ceramics was made. Southward, in the Mimbres Valley, beautiful black-on-white pottery was decorated with many realistic and conventionalized life forms. All these regions were deserted and uninhabited when the Spaniards arrived in the Southwest in 1540. Three important regions in the Southwest have been continuously occupied until the present time—the upper valley of the Rio Grande in New Mexico, the headwaters of the Little Colorado where the Zuñi now live, and the Hopi mesas in Arizona, in all of which there are easily distinguishable styles of pottery decoration. Some of the most striking characteristics for each region will now be mentioned.

The pottery of Mesa Verde may be distinguished by the rim formed by the continuation of the sides of the vessel without a definite inward or outward flare. The full thickness of the walls is maintained and the edge of the rim is flat. The slip is usually a grayish pearly white and the decorations are generally in bands of repeated designs, the key motif prevailing. These bands are bordered by lines of varying width, symmetrically placed above and below. Designs in hatching, are bordered by lines of the same width as those employed in the body. The flat topped rim usually has a row of dots.

The Chaco Cañon ware has a straight rim, rounded or sharp at the edges. The slip is very white and the figures are hatched in fine lines, somewhat wavy, and enclosed by much heavier lines. Frequently narrow lines are bordered with rows of dots.

The Kayenta ware of Kietsiel and Betatakin has a white slip nearly covered with black paint so that in some cases at least the white appears to form the designs. The bands have interlocking keys, frets, and double spirals. Designs are often made by cross hatching of considerable fineness resembling mosquito netting.

The Tularosa pottery on the upper Gila is noted principally for its modeling. One prevailing type consists of vessels which are molded to represent birds. They have vertical strap handles almost invariably terminating in modeled heads. The designs, which generally interlock, are made with solid black and hatching, nicely contrasted.

Not far south of the Tularosa region in the valley of the Mimbres a special style of black-on-white ware developed. Here are found bowls in complicated and very beautifully executed geometric designs. Solid black and hatch work are combined and often cover much of the surface of the vessel. The most astonishing characteristics are the realistic or slightly conventionalized animal figures. These are not only beautifully drawn but very interestingly spaced, often in opposed pairs. Frequently figures of this sort are blocked out in black within a delimited white field.

The four regions mentioned above were not occupied by pueblo-dwelling people at the arrival of the Spaniards and were probably deserted several centuries before that time. There remain to be discussed three districts which were occupied by villages when Coronado's expedition reached the Southwest in 1540. Two of these, Zuñi and Hopi, lie in the drainage of the Little Colorado River. Zuñi is situated in New Mexico, about forty miles south of the town of Gallup, near the headwaters of the Little Colorado, and the Hopi mesas are in Arizona, a considerable distance northwest of Zuñi. Between these still inhabited towns are many ruins of villages deserted before the Spanish occupancy of the country. All along the Little Colorado the earlier ruins yield abundant sherds of corrugated, black-on-white, and black-on-red pottery of the general character described above. At a later date the black-on-white ware was displaced by a more general use of black-on-red. In the Zuñi region a black glaze came to be used in place of black paint. The color of this glaze is not constant, varying toward green or purple. There also occurs along the Little Colorado, dating from prehistoric and early historic times, a ware with a buff or yellowish paste decorated in black, brown, and red. The designs on these vessels have a larger proportion of life forms and of representative or conventionalized decorations than are found in other parts of the Southwest. The most striking examples of this pottery are found at the two former Hopi villages, Awatobi and Sikyatki, which were abandoned in 1680.

The Rio Grande region in the northeastern portion of the Southwest shows a continuous record of pottery development from the early period of small family houses when the prevailing ware was corrugated and black-on-white, down to the present day when the potters of San Ildefonso are making wares for sale to tourists in quite new styles. The history of pottery development in this region has been recovered by the work of N. C. Nelson of the American Museum of Natural History and of Dr. A. V. Kidder of Phillips Academy, Andover, Massachusetts. Mr. Nelson worked intensively in the Galisteo Valley and by making sections of a rubbish heap brought the record up to 1680, when the Pueblo rebellion occurred and the region was deserted. Dr. Kidder, at Pecos, has

verified Mr. Nelson's findings and has extended the history to 1838, when that village was abandoned. In the Rio Grande region corrugated and black-on-white ware lasted until the time when large Pueblo structures were built. Then a gray type of pottery replaced the white and the designs were put on with a black glaze. Somewhat later the body of the designs was painted in dull red and outlined in black glaze. About the time of the Spanish occupation the glaze, for some cause, degenerated, and began to run badly during the firing process. About the time of the rebellion against the Spaniards in 1680, the use of glaze was abandoned and gray colored vessels were decorated with designs in dull red and black. The same general changes also occurred in the Zuñi region. This has been revealed by excavations at Hawikuh by Mr. F. W. Hodge of the Museum of the American Indian, Heye Foundation. In that region also there was a period during which glaze paint was used, which was followed by the manufacture of a polychrome ware.

MODERN WARE

The pottery vessels in the Southwest Indian Hall from the modern Pueblo villages were collected during the last thirty years, the larger number only twenty or more years ago. The striking differences, when these modern vessels are compared with the prehistoric wares, are to be found in the use of red as well as black in painting the designs, and in the prevalence of life forms.

The characteristic Zuñi vessel is an olla, nearly spherical in shape, but flaring toward the neck. The decoration most prized by the Zuñi shows a deer enclosed in a framework which is called his house, and near this a sunflower on which he is believed to feed. In drawing the deer the organs of the throat, mouth, and thorax are indicated, regardless of the fact that they are not in view when looking at the living animal. Scrolls and angular figures in solid color and hatching are also employed. The painting is in black and brownish red on a gray background. By these colors the Zuñi vessel is most quickly identified.

The walls of vessels made by the Acoma, near neighbors of the Zuñi, are sloping toward the bottom rather than rounded. The designs are in black and a yellowish red, often of a floral origin and cover two-thirds or more of the surface of the vessel, the lower portion being left solid red.

Santo Domingo ware is easily recognized by the nearly pure white glossy slip. The designs are usually in black only and are more open or widely spaced than in other modern ware, and frequently are purely geometric. Each village in the Rio Grande valley has in fact certain distinctive features in the shape and decoration of its pottery.

Recently, that is since 1921, a new ware has been made at San Ildefonso. The body of the vessel is a glossy black with the designs in a mat surface. The latter is obtained by the use of a paint which is made by mixing a powdered yellow stone with the syrup of the bee-balm. The ware is very pleasing and has found a ready market.

Among the Hopi, pottery is made at the present time only by the inhabitants of the First Mesa. Some years ago when the ruined village of Sikyatki, mentioned above, was being excavated a woman from the village of Hano named Nampeyo became interested in the pottery being recovered there. She began to manufacture pottery somewhat similar to this ancient ware, getting her inspiration from the designs she found upon it. Great quantities of this pottery are now produced on the First Mesa and sold to tourists. Much of it is quite unsuited to household uses. The older Hopi ware which has now been displaced was decorated in brown, black, and red designs on a dirty white slip which becomes covered with fine cracks.

Beside those described above which are used in the household or sold to tourists, vessels with a portion or portions of the rim projecting and terminating in terraces are made for ceremonial use. The painted decorations are symbolic, consisting of cloud designs and of life forms connected with water. The dragonfly is frequently represented. The cloud design consists of a group of semi-circles from which depend vertical lines indicating rain and with diagonals projecting upward to represent lightning. Such vessels are used to hold cornmeal and other sacred materials needed in the ceremonies.

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1. Pottery Making at Zuñi. The first step after the ingredients have been gathered and freed of foreign materials is to crush the dry clay and tempering materials with a hand stone, thus mixing them.

2. Pottery Making at Zuñi. When the clay and temper have been sufficiently pulverized they are mixed with water to make a paste and kneaded. In the photograph the decorated bowl contains prepared clay; the second bowl, water.

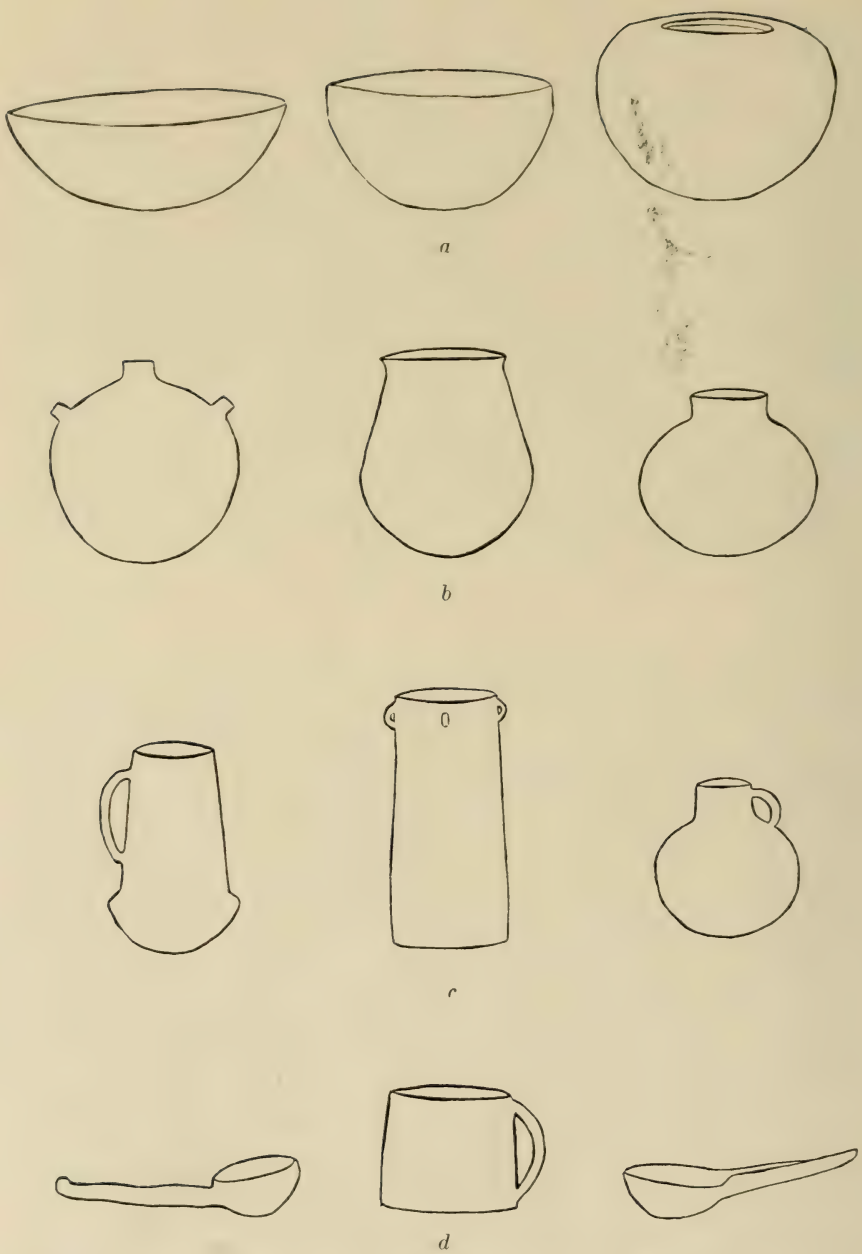
3–4. Pottery Making at Zuñi. The vessel is built up with rolls of clay applied spirally. In the upper illustration the potter is rolling out the clay preparatory to adding it to the already completed lower portion of the bowl. In the lower photograph she is adding a roll of clay with her left hand, while with her right she presses it to the edge of the preceding roll to hold it in place.

5. Pottery Making at Zuñi. When the pot has been built up to the desired size and shape the surface is smoothed with a molding tool. Throughout the process thus far the vessel is held in a base mold.

6. Pottery Making at Zuñi. The vessel has been removed from the base mold and a white slip, contained in the bowl in the foreground, has been applied. Then the white slip is polished with a rubbing stone.

7. Pottery Making at Zuñi. The red and black design is painted with a yucca leaf brush.

8. Pottery Making at Zuñi. The completed vessel is placed in an oven, covered, and fired.



9. Pottery Forms in the Southwest; a, Bowls; b, Ollas; c, Pitchers; d, Ladles and a Mug.

10. A Cooking Vessel of Corrugated Ware from the Aztec Ruin, New Mexico.

11. Sherd from a Basket-Moulded Unfired Bowl with a smooth interior and a plain rim added above the edge of the basket and a large lug. The tempering material was cedarbark.

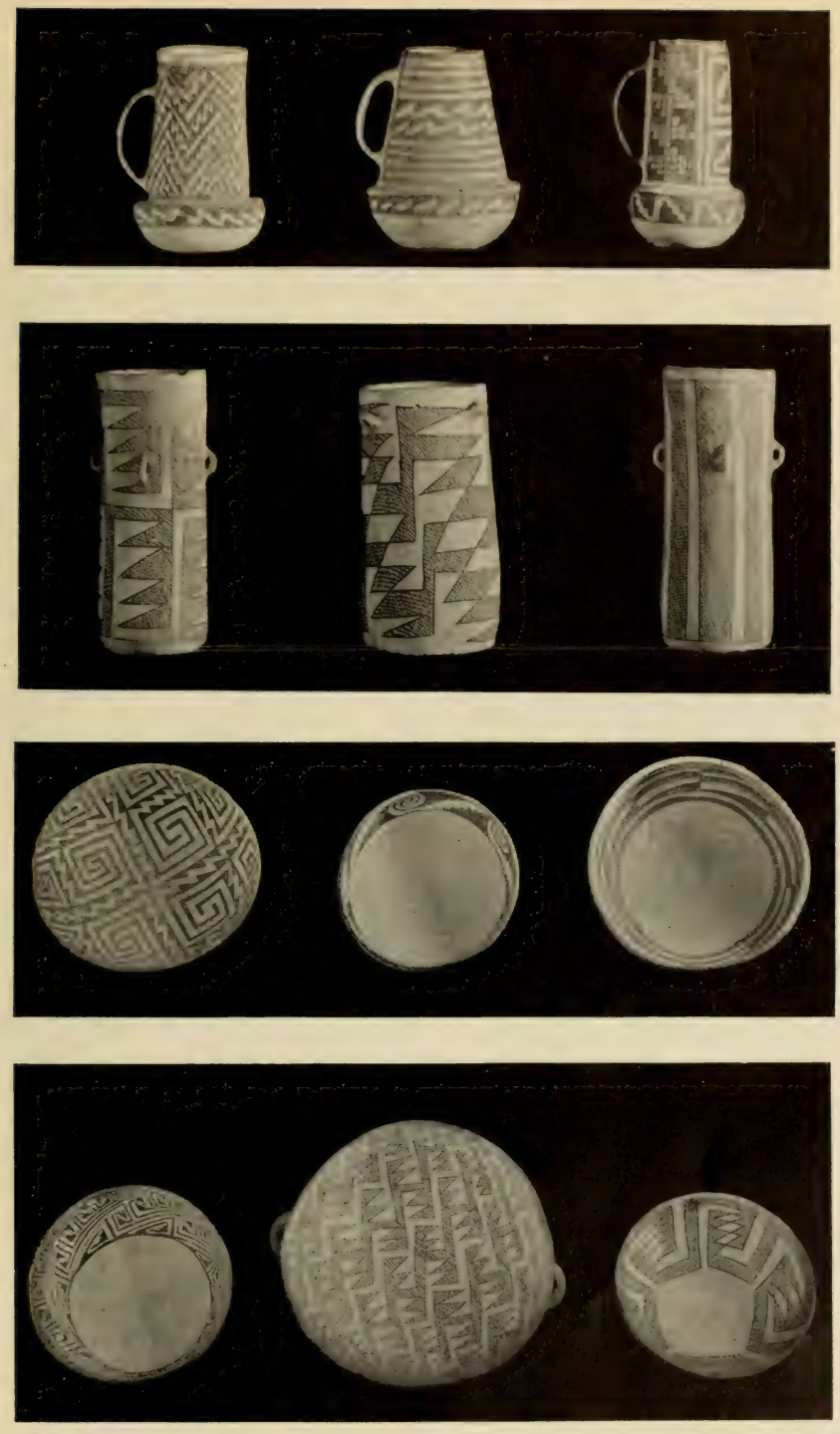
12. Culinary Vessels with Banded Necks, marking the beginnings of the technique later developed in corrugated ware. From graves on the Navajo Reservation.

13. A Bowl with the Decorative Value of the Corrugations further enhanced by the addition of an incised ornamental design.

14. Typical Bowls and Mugs with designs in black on a white ground, from the Aztec Ruin, New Mexico.

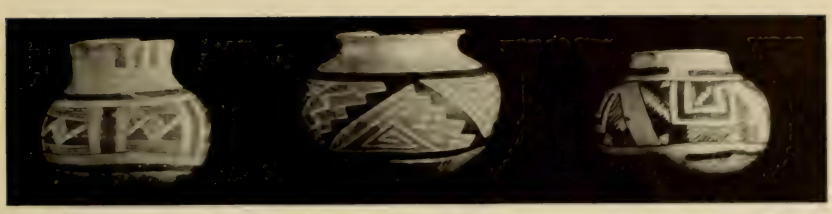
15. a–b, Interior All-Over Decoration on Black-on-white Bowls from the Aztec Ruin; c–d, Types of Zonal Ornamentation on Black-on-white Bowls from the Aztec Ruin.

16. Jars and Bowls of Black-on-white Ware from the Aztec Ruin and Pueblo Bonito, Chaco Cañon, New Mexico.



17. Pitchers, Cylindrical Jars, and Bowls in Black-on-white Ware, from Pueblo Bonito, Chaco Cañon, New Mexico.

18. Bowls in Black-on-white ware from the Mimbres Valley in southeastern New Mexico. Usually this interior decoration consists of one or two wide lines, or a series of fine lines, beneath which is a band of geometric decoration, leaving the bottom of the bowl free to receive distinctive treatment in the form of the realistic animal, bird, fish, insect, or human figures.

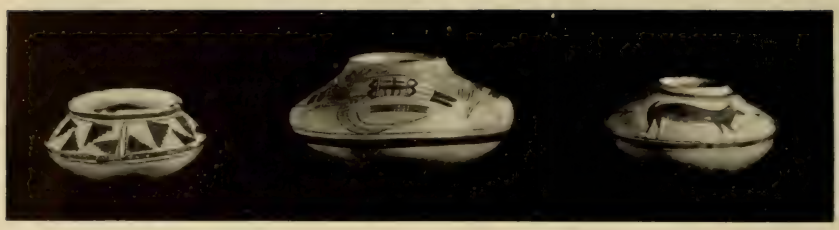


a

b

c

19. a–b, Jars and Bowls in Three Colors, Black-and-white on a red slip, from the Little Colorado region; c, Black-on-white pitchers, the commonest form in the Upper Gila Region, with striking interlocking designs and handles often modeled in animal form.

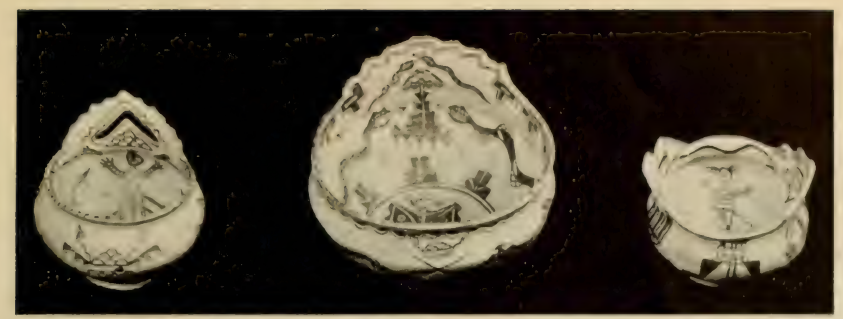


HOPI

HOPI

ZUÑI

20. Modern Pueblo Pottery



PRAYER MEAL BOWLS—SAN ILDEFONSO

STORAGE JARS—SAN ILDEFONSO

21. Modern Pueblo Pottery

LAGUNA

SIA AND SANTA ANA

SANTO DOMINGO

22. Modern Pueblo Pottery

FOR THE PEOPLE

FOR EDUCATION

FOR SCIENCE

THE AMERICAN MUSEUM OF NATURAL HISTORY

OUTPOSTS OF THE SEA

By ROY WALDO MINER

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OUTPOSTS OF THE SEA

ANIMALS OF THE TIDAL ZONE

By

ROY WALDO MINER

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A PICTURESQUE CORNER OF A TIDE POOL

A colony of sea anemones (*Metridium marginatum*), is clustered together on a rocky shelf. At the right, one or two anemones, sheltered beneath the floating rockweed, have ventured to expand their fluffy circlets of tentacles. Though of flower-like beauty in color and form, they are nevertheless voracious creatures, armed not only with tentacles but also with sting cells, with which they slay and capture small creatures, and even fishes which form their food. A number of the anemones have contracted, withdrawing mounth and tentacles within their bodies

ANIMALS OF A SUBMERGED SANDY SEA FLOOR

OUTPOSTS OF THE SEA

The Animals of the Tidal Realm—Marine Hosts that Today Assail Our Continental Borders, Endeavoring to Repeat the Conquest Attained Ages Ago by the Ancestors of the Present Land-animals

By ROY WALDO MINER
Curator of Marine Life, American Museum of Natural History

THE daily rise and fall of the tides along the seacoast alternately submerges and lays bare a strip of the shore which varies in width from place to place according to the local range of the tide.

Thus, the vertical rise of the tides off the New England coast south of Cape Cod is only from one to two feet. Within Cape Cod Bay and Massachusetts Bay, on the other hand, it rises nine to ten feet. This is also true along the Maine coast, where the tides are deflected to the northwest by the curvature of the shore, joining the incoming waters farther north. These, in turn, are finally compressed into the narrowing funnel of the Bay of Fundy with the result that huge tides of thirty to forty feet are created at its tip.

In Passamaquoddy Bay, New Brunswick, the rise is twenty-two feet, and this is the extent to which it covers the vertical cliff-walls of Bliss Island, at the entrance to the bay. St. Andrews Point, within the same bay, has a very gradual slope, and, at low water, is uncovered for two miles. Hence, the tidal zone varies greatly in area.

The nature of the substratum composing it also differs. It may be of rock in the form of vertical cliffs, as above mentioned, or sloping and, perhaps, broken into terraces. On the exposed shores it may consist of sand beaches, or mud flats in sheltered coves and bays. It may be covered by rocky bowlders, broken down from the cliffs by wave action, or eroded out from headlands of glacial drift by the washing away of the soil enclosing them.

The animal and plant life of the permanently submerged continental shelf has oveflowed into this stretch of semi-

Photograph by Mary C. Dickerson

A SAND BEACH AT LOW TIDE, WOODS HOLE, MASSACHUSETTS
Long lines of seaweed, thrown up by the waves, are arranged in ribbon-like bands, beneath which sand hoppers and beach fleas are concealed

terrestrial, semi-marine territory. The continental shelf is the submarine continuation of the tidal zone seaward. It slopes gradually to about one hundred fathoms, beyond which the bottom falls more rapidly to the greater depths of the ocean. This outer face of the shelf is known as the continental slope, and varies in its abruptness from a clifflike drop to a gradually accelerated gradient continuing the surface of the shelf itself. The width of the continental shelf also varies considerably. It is extremely wide in the North Atlantic, from the American side around to the British Isles, but quite narrow off Spain and Portugal and the western coast of Africa.

It is believed that the comparatively shallow waters of the continental shelf and slope witnessed the great evolution of marine life. Here it became diversified and abundant, for here the conditions of life are at their best. From this region marine creatures were crowded out into the deeper oceanic waters, on the one hand, or specialized for the pressures and darkness of the deep abysses. On the other hand, they invaded the tidal zone, the fresh waters and, finally, the land. The evidence is strong that wherever and whenever life originated, the continental shelf is the region of its greatest evolution and the center of its radiation. The very fact that its location has shifted during geologic ages, as the continental areas were thrust upward or were worn down again through erosion, until the continental shelf invaded their lower reaches as epi-continental seas, has caused the living creatures inhabiting the shallow waters to be subjected to varying conditions and an intense struggle for existence, resulting in the preservation of adaptive changes and the elimination of those that were nonadaptive. As we see it now, the tidal zone and its inhabitants

represent a present-day phase of that struggle, for here only those sea creatures can exist that are adapted to the strenuous daily changes of environment involved in being alternately exposed to the air and submerged by the tidal flow. It is so striking an example of the results of natural selection on a large scale, and so accessible to everyone, that the thinking visitor to the shore will have no difficulty in reading the chief lessons taught by the inhabitants of the tidal region.

In the first place, it must be remembered that the tidal zone is the pulsating border of the great life-association of the submerged continental shelf. Secondly, life is so abundant that animals and plants of all species not only live where conditions are appropriate and easy for them, but also struggle to live under adverse circumstances. Those that inhabit the totally submerged shallow seas find life comparatively easy, exposed as they are to the sunlight, yet covered by oceanic waters chemically harmonious with their body fluids—a fluid hydrosphere filled with food and replete with oxygen for the animals, and carbon dioxide for the plant life. Nevertheless, many also struggle to live under the more trying conditions of the tidal zone, where they maintain their position in proportion to their hardiness and their capacity to withstand exposure.

Everyone who walks along the shore at low tide is familiar with the zonal or banded distribution of the animal and plant forms. This is especially conspicuous on the rocky shores of New England, north of Cape Cod. The white band of rock barnacles (*Balanus bala-*

THE CLIFFS AT NAHANT, MASSACHUSETTS, AT LOW TIDE

The tidal zone is clearly marked on the vertical rocky face, as a band nine feet in width, showing the white frieze of barnacles above the stratum of seed mussels and rockweed which extends to the water line. A rock tide-pool, overarched by a weed-festooned natural bridge, is shown in the foreground. This locality is reproduced in the American Museum as the "Tide-Pool Group"

A CROWDED COLONY OF MUSSELS AND BARNACLES

Both mussels and barnacles can withstand long exposure to the air by enclosing enough sea water within their shells to keep their breathing organs moist. Together with the periwinkles (*Littorina litorea*) and "purple" snails (*Thais lapillus*), they invade the upper regions of the tidal zone. The snails, especially, suggest a transitional stage toward terrestrial life

noides) is displayed at the summit of the zone, their close-set marble wigwams crowding each other to form a snowy frieze. Ambitious periwinkles (*Littorina litorea*) swarm here and there, climbing slowly but surely upward over the housetops of the barnacle colony, and even mounting far up the bare rocks above it.

The barnacle frieze is overlapped below by the rockweeds (*Ascophyllum nodosum* and *Fucus vesiculosus*), their olive-brown fronds draped in graceful fringes down to the water's edge, disclosing beneath their parting masses the continuous embossed mosaic of the black edible mussel (*Mytilus edulis*), which encrusts the rock up to the lower limit of the barnacle zone. Bright patches of gaily colored and banded "purple" snails (*Thais lapillus*) may be seen grouped upon the mussel colony, which extends downward and below the water mark. Here it is succeeded in turn by another zone characterized by the green sea urchin, a small animal rejoicing in one of the longest scientific names known to zoölogy, *Strongylocentrotus droehbachiensis*.

The sea plants below the rockweed zone include the common pink coralline (*Corallina officinalis*), the Irish moss (*Chondrus crispus*), and the dulse (*Rhodymenia palmata*). These are laid bare only by the lowest tides, and even then are continuously washed by the surf. Also at this level the two species of the common sea star (*Asterias vulgaris* and *Asterias forbesi*) are to be found, the former varying in color through red, orange, purple, and blue, and distinguished by a white spot, the ambulacral plate, between two of its arms. The latter is usually greenish brown, with a bright orange ambulacral plate. Associated with them are the common sea anemone (*Metridium dianthus*) and two species of rock crab (*Cancer borealis* and *Cancer irroratus*).

This zonal arrangement depends upon two main factors, the exposure factor

and the food factor. It is obvious that the height above the low-water mark at which a sea animal can live depends upon its ability to withstand exposure to the air, for the upper limits of the tidal zone are, of course, left bare the longest. The periwinkle, in fact, is far on the way toward adaptation to terrestrial life. As the tide falls, it captures a few drops of water, which bathe its breathing organs and are kept from evaporation by a closely fitting horny plate closing the shell-opening. In this way it may remain many hours out of water. It is a vegetarian, feeding not only on the surface of rockweed, but also on minute algæ high on the rocks and among the barnacles.

The barnacles likewise are provided with means of retaining a few drops of moisture or moistened air beneath four little valvelike plates that close the top of their shells. They feed on the microscopic diatoms brought on the crest of the incoming tide. When they are submerged, each barnacle may be seen to unfold its quadripartite doors, whereupon the little plume of feathery feet waves to and fro, and, like a casting net, captures its tiny prey, which is immediately withdrawn within the closing gates. Agassiz has said that a barnacle is nothing but a shrimp standing on its head within a marble house, kicking its food into its mouth with its feet!

The mussels, occupying the zone immediately below the barnacles, can withstand exposure, but for a shorter time. They, too, feed upon diatoms. Both mussels and barnacles are preyed upon by the voracious "purple" snails, which also can withstand exposure at low tide, though many remain hidden under the moist drapings of rockweed.

The mussel zone is limited above by the barnacles, which tend to spread over the mussel shells and choke them by their more rapid growth, and below, by the zone of green sea urchins, which feed

COLLECTING IN THE TIDE POOL AT NAHANT, MASSACHUSETTS

Basins and crevices in the rocks remain filled with water when the tide falls below their level, and thus harbor not only the life of their own zone, but also many creatures which ordinarily live below the low-tide mark

upon the mussels. The latter are also preyed upon by dog whelks (*Buccinum undatum* and *Lithodomus decemcostata*), two large snails found on our northern rocky shores. The whelks bore round holes into the mussel shells and suck out the animal.

Down near the low-water line voracious sea stars envelop the mussels with their arms, attaching their tube feet to the opposing valves, which they pull apart by gaining a purchase with their arm tips on the surrounding substratum. Then each sea star protrudes its saclike stomach from the central mouth on the underside of its body, and inserting it between the valves of the mussel, pours out its digestive fluid. Thus, it digests the poor creature within its own shells, while it absorbs the fluid products of digestion through its stomach walls. Sea stars devour oysters even more voraciously, and are the most hated enemies of the oyster fisherman.

On terraced and sloping rocky shores there are many crevices and basins that are left filled with water at low tide. These occur at various levels and, in the lower part of the tidal zone, are especially rich in concentrated animal and plant life appropriate to the level at which they occur, and also to all the zones below that level. At flood tide they are invaded by the eggs and larvæ of many creatures usually found only below the low-water mark, which are able to live and develop in the pools because these are always filled with water. Thus the pools become veritable sea gardens of great beauty and fertility.

Here gay-colored sea stars occur in great abundance, hiding in crevices between bowlders covered with velvety brown Irish moss glimmering with iri-

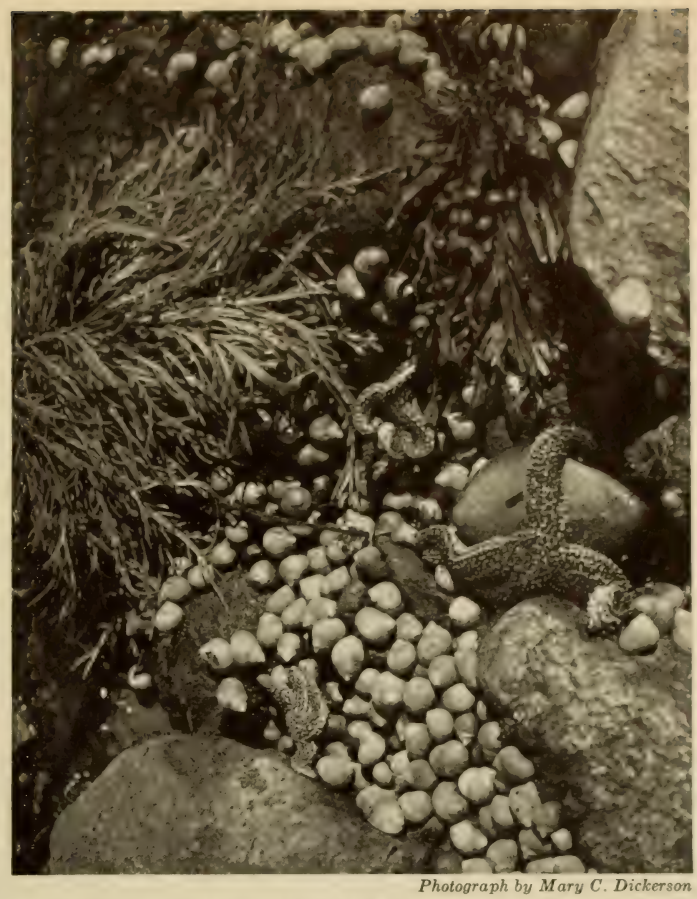
Photograph by Mary C. Dickerson

A SEA ANEMONE WITH BEAUTIFULLY EXPANDED TENTACLES

These flower-like animals (*Metridium dianthus*) live at or below the low-water mark, often in great numbers. Their petal-like circlets of tentacles are armed with sting cells and surround a central mouth. Free-swimming creatures, including small fishes, are caught, stung to death, and devoured. The anemones vary widely in color, from brown through pink, cream, white, and deep orange

descent violet tips and overhung with clustered chimneys of the gray-green crumb-of-bread sponge (*Halichondria panicea*). Feathery, ruby-hearted hydroids (*Tubularia crocea*) fringe a shelf occupied by sea anemones with their rich stock-in-trade of color, ranging from brown, mottled with white, through plain white to rich pink and deep orange.

Two green crabs (*Carcinides mænas*) are sparring with each other in a corner beneath the ruffled overhanging fronds of the brown kelp (*Laminaria agardhii*). The entire rock surface, lining the pool, is gay with sea mosses or encrusted with red-purple and brown calcareous algæ. Thus the pool is replete with life, refreshed and renewed by the periodic incoming tides with their floods of food and oxygen.



Photograph by Mary C. Dickerson

PERIWINKLES AND SEA STARS EXPOSED AT LOW WATER

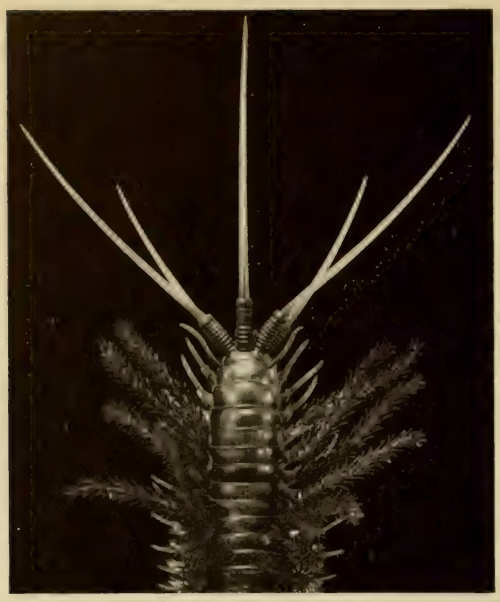
The ubiquitous periwinkles are abundant near the low-water mark, as well as in the upper reaches of the tidal zone. The sea stars, on the other hand, can withstand exposure for only a short time, and are therefore confined to the lower part of the tidal zone and the waters below the low-tide mark

While the northern New England shore is characterized by its rock-bound coasts, sandy beaches occur here and there, hemmed in by granite headlands, and mud flats are found in sheltered locations. But southern New England is typically low and sandy, beginning with the great sand spit which is Cape Cod. This forms a barrier hindering, to a degree, the intermingling of northern and southern forms.

Animals of the rocky coasts and regions of high tides must be adapted for clinging to crevices and for withstanding the battering of the waves and the rush of tidal currents. Animals of sandy and muddy regions, on the other hand, tend to be of burrowing habits, while the surface-living creatures are scavengers.

A sand beach, at low tide, appears to be a particularly barren place. Yet the close observer will detect signs of life. For example, he may chance upon little heaps of sand here and there, which betray the presence of the sand-collar snail (*Natica duplicata*).

If one waits till the tide begins to rise and covers these burrows, a stirring of the sand may be seen, and soon the snail will issue forth and crawl slowly over the



THE PLUMED WORM

This martial looking knight (*Diopatra cuprœa*), of the sea bottom, lives in a chimney-like den, the upper portion of which projects into the water above the ocean floor

sea bottom. As it unfolds its foot and expands its "apron," it seems impossible that so huge a creature could have been packed into a spherical shell the size of a tennis ball. Above the apron it waves a pair of tapering tentacles, furnished with eyespots near the base.

The egg-case of this snail is a flat, nearly circular, collar-shaped structure, to which the sand adheres. The underside is completely lined with transparent, beadlike eggs. These sand collars are often picked up on the beach in a dry condition, when they crumble at a touch.

Other burrowing animals of the sand beach are the razor-shell clam (*Ensis directus*), so called from its elongate bivalve shell suggesting the handle of an old-fashioned razor; the lady crab (*Ovalipes ocellatus*), a swimming crab with hind legs terminating in oval paddles and a carapace beautifuly marked with

A FLEET-FOOTED INHABITANT OF SAND BEACHES

The ghost crab (*Ocypoda albicans*) is aptly termed, for its light, sandy markings so closely resemble the color of the beach, that it flits like a shadow along the shore and seems actually to disappear from the sight of the observer when it comes to rest

Photograph by Mary C. Dickerson

A COLONY OF GREEN SEA URCHINS

These sea urchins (*Strongylocentrotus droehbachiensis*) are abundant at or below the low-water mark on our northern rocky coasts. They feed upon the edible mussels (*Mytilus edulis*) and both, in turn, become the prey of the voracious sea stars (*Asterias vulgaris* and *forbesi*)

small purplish spots; and the ghost crab (*Ocypoda albicans*), found on sandy beaches from Long Island southward. This crab makes its burrows above the low-water mark and its whitish carapace so closely imitates the sand that it is difficult to see it, except when in motion. It runs with great speed, and, when it stops, seems to disappear.

Mud flats are especially rich in sea life. Everyone is familiar with the great stretches of edible mussels (*Mytilus edulis*) that are found on certain mud flats between the tides, and the kind of sandy mud in which one digs for clams, whether the soft clam (*Mya arenaria*), or the "hard shell" (*Venus mercenaria*).

But let us take a water glass (which is just a bucket with a glass bottom), and wade at low tide in a sheltered cove near the edge of a patch of eelgrass. Where the shallow sea floor is composed

A MEMBER OF THE STREET-CLEANING FORCE OF SHALLOW WATERS

The hermit crab (*Pagurus pollicaris*) is one of the scavengers of submerged, muddy sea bottoms

SEA STAR DEVOURING OYSTERS

The sea star mounts the shells of the living oyster with its five arms partly enfolding the two valves of its victim. It then applies its hundreds of tube-feet to the outer surface of the shells by means of small terminal suckers. With the tips of its arms it braces itself against the surrounding objects and exerts a strong, steady pull, that gradually forces the oyster shells apart

of sandy mud, let us place the water glass on the surface and look through it. A busy scene at the edge of a miniature submarine forest composed of the eelgrass roots, is disclosed to our eyes. Tiny hermit crabs (*Pagurus longicarpus*) are scuttling to and fro. Soon they gather about a bit of decaying substance and immediately begin to pull it apart. Mud snails (*Nassa obsoleta*), attracted by the tumult, crawl up from various quarters, leaving a little groovelike track in the mud behind them. A larger hermit (*Pagurus pollicaris*) lumbers along and scatters the smaller fry as he pulls the decaying morsel to pieces. Small, transparent shrimp (*Palæmonetes vulgaris*) dart in to get their share.

The hermits, the shrimp, and the mud snails are the scavengers of shallow water —the street-cleaning department of the submerged mud flat—and they are thorough in their work. It is true that the hermits acquire their uniforms by theft, for they appropriate the shells of sea snails. Sometimes they find them empty and ready for use. At other times, they are said to eat out the former occupant first, thus obtaining a meal and a home simultaneously. When they grow too large for the shell they happen to have, they hunt for another, and it is amusing to see them make the change. They leave the old shell and, quickly settling into the new one, try it a few seconds, then change back to the old home. After a short interval the new shell is tried again, and the process is repeated several times. In the end, the hermit may walk off with the old shell after all!

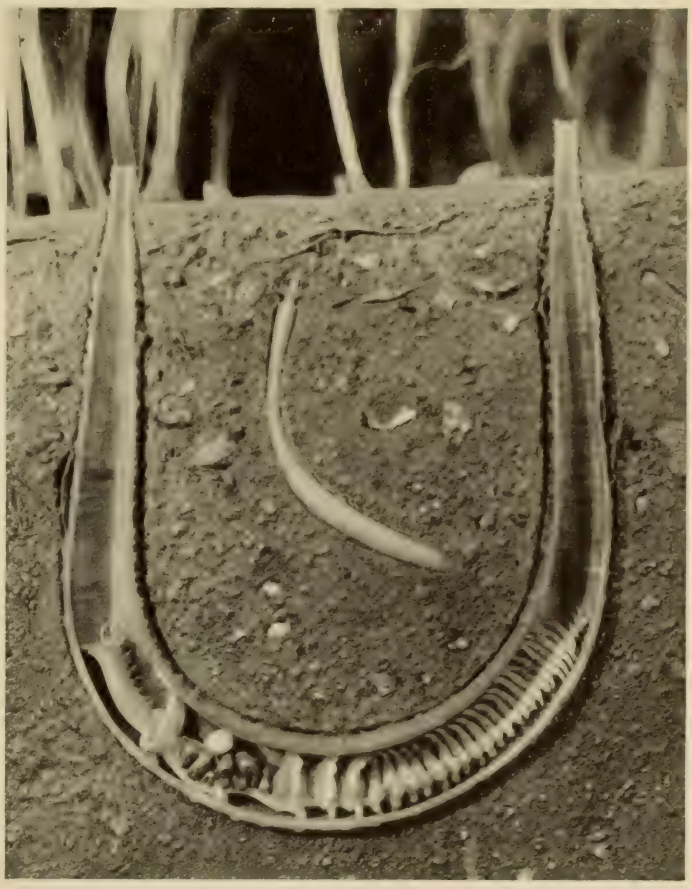
We now direct our gaze at the shallow

sea floor in the clear space between the eelgrass and the shore. Here on the sandy mud we begin to see certain details that hitherto have escaped our attention. Clusters of broken shell and bits of seaweed, apparently caught together by the currents, now resolve themselves into neatly cemented chimneys leading to some underground abode, for gently waving filaments projecting from the summit betray the existence of an occupant.

We carefully dig down into the sea bottom around the structure and remove a long, tapering, parchment-like tube, with the thickened chimney of shell-fragments at the top. After washing it, we cut it open in a glass dish of sea water, and out floats a beautiful, struggling creature, clad in segmented steel-blue armor, and bearing several sets of blood-red plumes upon its shoulders, while five tapering, lancelike palps are flourished in front. This knight of the submarine castle is the plumed worm (*Diopatra cupræa*).

Likewise, paired chimneys of smoother texture a little nearer the shore cause us to dig up a U-shaped tube, also of parchment, belonging to the parchment worm (*Chætopterus variopedatus*). This is the most curious worm of all. It is a strange creature with a flat, shovel-like head, armed with bunches of golden bristles, behind which is a pair of long arms having grooves lined with moving cilia. Then comes a pulsating cup, attached to the upper side of the body, followed by three disc-shaped segments, and last of all is the tapering tail, disclosing through its transparent walls an internal structure brightly colored green, yellow, and pink.

The parchment worm lives in the bottom of its tube, the three disc-shaped segments fitting the cavity neatly. As



A BUILDER OF SUBWAYS BENEATH THE SEA

The parchment worm constructs for itself a U-shaped tube formed of a gluelike secretion from glands in its own body, which hardens into a parchment-like substance upon contact with the sea water. The strange looking architect lives in the bottom of his home, the two chimneys of which project into the sea. By means of three disclike segments in the middle part of its body, which just fit the interior of the tube, the creature pumps a stream of water into one chimney and out through the other, from which it abstracts the microscopic creatures that form its food

ANIMALS OF THE WHARF PILES

The piles of old wharves along our shores are completely covered with a great diversity of animal forms, all of which are adapted to filtering out the microscopic food from the sea water in which they are submerged

the worm contracts its body rhythmically, these segments move like the pistons of a suction pump, drawing a stream of water into one chimney, passing it through the tube, over the body of the worm, and out the other chimney. The microscopic food contained in the sea water is filtered out by the combined action of the arms and moving cup, and transported through a trough lined with moving hairs up the mid-line of the body to the mouth of the worm.

It is obvious that not only the sea bottom, but the soil beneath the sea as well, is alive with myriads of creatures, adapted by their structure for breathing and obtaining their food in this particular habitat. Likewise, if we examine the wharf piles of an old wharf, we shall find it clothed completely with sea grapes, tube-building worms of brilliant, flower-like hues, feathery hydroids, scarlet sponges, mussels, sea anemones, members of every animal phylum, all adapted to a stationary form of existence, equipped with various contrivances for extracting minute creatures for food from the life-giving sea in which they are bathed.

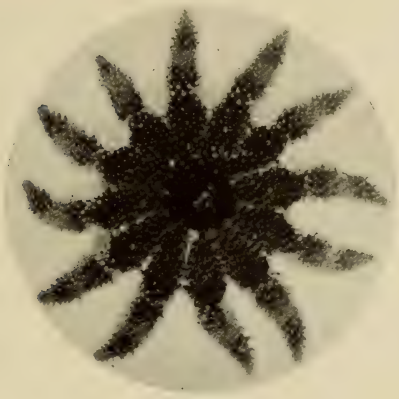
Life pulsates wherever we search along the borders of the sea. Living creatures endeavor to occupy every kind of habitat, and, if it is favorable, swarm through it so vigorously that all the space is occupied and many are crowded to the limits where marine life is precarious.

The pressure to escape to an air-breathing existence drives certain species to the limit of the tidal zone, so that we see, at the present time, compromises between the marine and terrestrial form of life, as in the case of the periwinkles and purples among mollusks. These are closely related to other snails (*Ampullaria* and *Siphonaria*) which have both water-

breathing branchiæ and air-breathing lung, and finally the snails, *Cerithidea* and *Cyclophorus*, terminate the series with a complete air-breathing apparatus. The same pressure now continues which, in the Carboniferous Age, forced the conquest of the air by the lowly progenitors of the land vertebrates.

The comparative anatomy of marine invertebrates shows us that there has been a gradual closing of the body cavity and circulatory system in higher marine animals, thus segregating the body-fluid which bathes their tissues and is closely similar in composition to the salt solution that we call sea water. It is very significant that the inorganic salts of the blood of terrestrial animals are the same as those found in the ocean.

Thus the water of the seas, closely adapted in its composition for the life requirements of the lowest marine creatures and circulating freely through their cavities, has been succeeded by a fluid closed off from the outside within the bodies of higher organisms, some of which finally shook themselves free of their ancestral abode and emerged into the upper air. It is almost as if the invaders of the land carried a portion of their original habitat enclosed within them to bathe their tissues with the precious sea environment and so insure their continued existence in their new world.



THE SUN STAR OF OUR NORTHERN SHORES

This brilliant creature, (*Solaster pappposus*), bright scarlet with white-banded arms, is one of the most conspicuous inhabitants of our rocky coasts

FOR THE PEOPLE

FOR EDUCATION

FOR SCIENCE

HOW OLD IS THE EARTH?

BY CHESTER A. REEDS

GUIDE LEAFLET SERIES, No. 75

THE AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK, N. Y.

Reprinted from Natural History, March-April, 1931

THE INNER GORGE OF THE GRAND CAÑON OF THE COLORADO RIVER

From a Painting by Gunar Wildforss, 1930

LINCOLN ELLSWORTH COLLECTION

VIEW looking west-northwest across the mouth of Bright Angel Cañon from near the Kaibab Suspension Bridge. The Colorado River is in the left center, and flows here at an elevation of 2450 feet above sea level. The varied rocks of the north wall of the inner gorge appear in the foreground and in the mid-distance, with the isolated Tower of Set, 5997 feet, appearing in the background, left center. In the right center the towering mass of the Cheops Pyramid, 5350 feet, crowns the slope to the inner gorge. The twin peaks of Isis Temple form the highest elevation 7028 feet, in the right background. To the south of the river in the left margin appears a portion of the rocks in the south wall of the inner gorge with the isolated peak of Dana Butte, 5025 feet, prominently in the background.

The geological section, which is of special interest, is explained more fully in the article "How Old Is the Earth ?"

HOW OLD IS THE EARTH?

BY CHESTER A. REEDS

MAGNA OPERA DOMINI · EXQUISITA IN OMNES VOLUNTATES EIUS ·
THE AMERICAN MUSEUM OF NATURAL HISTORY
INCORPORATED
1869
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GUIDE LEAFLET SERIES No. 75

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THE COLORADO RIVER AT THE BOTTOM OF THE GRAND CAÑON OF ARIZONA

HOW OLD IS THE EARTH?

The Earth Reveals Its Age By Hour-glass Deposition of Sodium and Sediments, and the Atomic Disintegration of Radioactive Elements

BY CHESTER A. REEDS

Curator of Geology and Invertebrate Palæontology, American Museum

IT may be stated at the outset that nobody knows just how old the earth is. There are certain criteria available, however, which indicate that the oldest rocks are of the order of 2000 million years. There are data which imply that the upper limit of the age of the minerals is about 3000 million years. This may be considered the lower limit of the age of the earth's material. Iron meteorites have been analyzed which yield a maximum age of 2600 million years. These are stupendous figures. The lower figure of two billion years as a minimum age for the earth implies that it has encircled the sun as many times, and that during this period it has turned on its axis 730,500,000,000 times to afford as many days of light and darkness.

The presence of ripple marks, sun-crack impressions in muds, water-worn pebbles, rounded sand grains, seasonally banded clays, limestone deposits, and vestiges of primitive forms of life in rocks of very ancient origin, all point to physical conditions on the surface of the earth that are similar in every respect to those enduring today. Various folded gneisses and schists, without vestiges of life, much distorted and frequently impregnated with volcanic injections, constitute the oldest rocks exposed on the earth's surface. The earth, although very old, has a remarkable history. The various steps in its development are in some instances still obscure, but they are becoming more apparent with the growth of knowledge concerning the earth.

Spectroscopic analyses reveal that 49 of the 90 chemical elements found on the earth have been recognized in the sun. In fact, astronomy teaches that the 1091 members of the solar system have originated from the same material. Various theories as to the origin of the earth postulate that the earth and the other

planetary bodies in our solar system were born of our sun when it was in a giant-star stage. This transformation of the sun is supposed to have been induced by the close approach of a passing star several times more massive than the sun itself. The resulting effect of such a close approach was the setting up of great tidal stresses in the sun and the drawing out of two long filaments of gaseous matter from opposite sides of the sun's surface. After the large star passed on, the filament on the far side of the sun as well as a portion of that on the near side may have been drawn back into the sun; however, a considerable portion of the filament remained in space subject to the influence of the sun. In the course of time the matter in this filament was gathered together about certain nuclei to form the nine planets and their satellites. The material was originally in a gaseous state. Later it passed to a liquid state through loss of heat by radiation from its surface, and finally, as in the case of the earth, into a solid state, at least for the outer crustal portion which may be 40 miles in thickness or about 1/200 of the radius of the earth.

American Museum of Natural History

A STONE METEORITE, JOHNSTOWN, COLORADO, METEORITIC SHOWER

This stony meteorite weighing 42 lbs. 8 oz., was seen to fall following four explosions, at 4:20 P.M., July 6, 1924. It is coated with a thin black crust. The gray stony matrix of the interior is shown by the white spots where the crust has been peeled off

The meteors, which enter the upper levels of the earth's atmosphere in great numbers, estimated to be 20 million per day, may be remnants of the original filaments, or of like matter from outer space. Most of these meteors are small, one to two-tenths of an inch in diameter. Upon entering the earth's atmosphere they travel at planetary velocities varying from 9 to 47 miles per second. Due to the great resistance offered to their passage by the earth's atmosphere, which is estimated to be 90 to 100 miles in thickness, the solid portions of most meteors burn up before reaching the earth. In addition to the ash of burnt-out meteors a minimum of one meteorite per day reaches the earth's surface.

The portions of 700 meteoritic falls exhibited in various museums are composed primarily of either nickel-iron, or of stone specimens, or, of combinations of these two kinds of matter. The stony meteorites resemble the light colored felsitic lavas of the earth. There are differences in texture in each, however, which the skilled observer readily detects. The iron meteorites with nickel, troilite, carbon, and other inclusions are not found duplicated on the earth. Some 29 elements found on the earth have been detected in meteorites. On the other hand, six mineral compounds have been noted in meteorites, which have not been found on the earth.

It may be stated thus that the earth, the meteorites, the sun, the moon, and the stars are distantly related. The earth and its moon with diameters of 7918 and 2162 miles, respectively, are intimately related to the sun, which is 866,400 miles in diameter. Although their densities, as compared with equal volumes of water, vary, the density of the earth being 5.52, the moon 3.40, the sun 1.39, these differ-

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THE MYSTIC POWER OF THE COLORADO RIVER IN ARIZONA

A view from the upwarped plateau rim, 7000–8000 feet above the sea, into the outer and inner gorges of the Grand Cañon where the river flows at a level of 2400 feet. This cañon is 217 miles long, from 8 to 20 miles wide, and more than a mile deep. It was eroded by the river during the last one million years

ences are explained by the different states of like matter, the earth and moon being solid and the sun gaseous. The fact that the earth rotates on its axis at a rate of 18.5 miles per second, and about the sun at a rate of 66,000 miles per hour, also implies that the mass of the earth, which weighs 6590 million million million tons, is controlled by the larger mass of the sun, which revolves once on its axis in 25 days, and weighs 1.983×10^{33} grams.

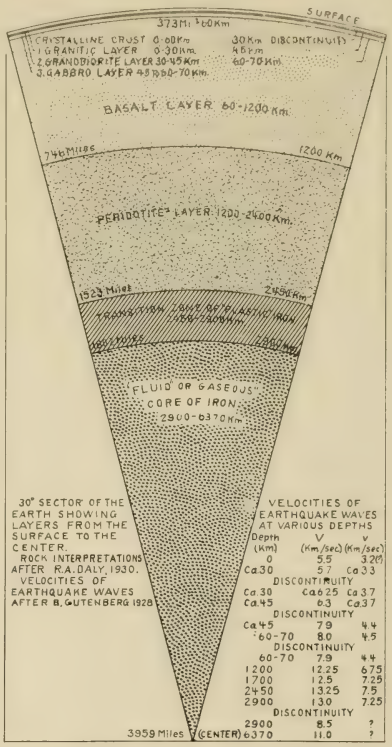
The various stages involved in the upbuilding of the earth are of interest in discussing its age. No two theories agree, however, on the number of steps involved, nor in the way in which it was accomplished, yet most of them assume that in the beginning the materials of which the earth is composed were in a gaseous state. The number of years required for a planet having the size and density of the earth to pass from a gaseous to a solid state is of course problematical.

According to the Planetesimal Hypothesis proposed by the late T. C. Chamberlain and F. A. Moulton of the University of Chicago in 1905, all but the central core of the earth, which is 4346 miles in diameter, has been built up by the infall of planetesimal matter. Since but a small amount of such planetesimal, or meteoric matter, is now added daily to the earth, the hypothesis implies a great age for the earth. Chamberlain held that at the present rate of fall it would require 1,000,000,000 years to form a layer of meteoritic material one inch in thickness on the earth. J. Barrell (1923) took exception to Chamberlain's views and argued for a molten condition of the earth at the completion of its growth. He assumed that the earth developed rapidly by the infall

of planetoid-like bodies rather than by the slow accumulation of dustlike particles. He was of the opinion that all of the near-by planetoids, even those several hundred miles in diameter, except the moon, had been gathered in by the time the earth attained a condition of stability and completed growth.

Present knowledge of the earth indicates that it has a shell-structure. The past thirty years of seismological research have led to this definite conclusion. Besides the solid crust which is composed of a somewhat heterogeneous mixture of sedimentary, igneous, and metamorphic rocks, there are successive zones of material and a central core which differ from one another in density, in chemical composition, and in elasticity. The earth as a whole is more rigid than steel. Earthquake waves are transmitted through it. Each earthquake records three principal kinds of waves on a seismograph, namely: primary, secondary, and main waves. The primary or longitudinal waves pass through all portions of the earth. The secondary or transverse waves, a kind developed only in solids, pass through only the outer portion of the earth; they do not pass below a depth of 2900 km. It is at this depth, 0.45 of the radius of the earth, that the inner core begins. Since this type of wave is not transmitted through the inner core, this portion of the earth is believed to be in a liquid or gaseous state. The main waves which are the largest and last to be recorded, are confined to the crust of the earth.

The velocity of the primary and secondary waves at various depths, V and v respectively, as determined by B. Gutenberg, 1928, and the nature of the rock in the respective zones, as interpreted by R. A. Daly, 1930, are given in the accompanying sketch of a 30 degree sector of the earth. The density of the various zones is noted in the text below.



A 30° SECTOR OF THE EARTH

SHOWING LAYERS FROM THE SURFACE TO THE CENTER. THIS DIFFERENTIATION OF THE INTERIOR OF THE EARTH INTO ZONES IS BASED UPON VARIATIONS NOTED IN THE TRANSMISSION OF EARTHQUAKE WAVES THROUGH THE EARTH. THE INNER CORE DOES NOT TRANSMIT THE SECONDARY OR TRANSVERSE SEISMIC WAVES, A KIND DEVELOPED ONLY IN SOLIDS, HENCE, IT IS BELIEVED TO BE IN A "LIQUID" OR "GASEOUS" STATE

It may be noted that the crystalline crust is 60-70 km. in thickness. In addition to the outer sedimentary layer, which varies in thickness from 0-5 km. with density 2.7, the crust is composed of three zones of rock each separated by planes of discontinuity as follows:

(1) granitic layer 0-30 km. in thickness, density 2.7

(2) granodiorite layer 30–45 km. in thickness, density 2.7+

(3) gabbro layer 45 to 60-70 km., density 2.9.

Below the crust lies a hot, vitreous, basaltic layer 60-1200 km. in thickness, density 3.3. This is followed by a layer 1200–2450 km. in thickness, which Daly believes may partake of the nature of peridotite, while H. Jeffries (1929) refers to it as the dunite layer, density 5.0. At a depth of 2450–2900 km. there occurs a zone composed perhaps of plastic iron,

density 9, where seismographic waves slow down. This would indicate that it is transitional in character from the more or less silicate layers above to the great inner core of the earth below. The inner core with great pressures and temperatures resulting from its superimposed load is believed by H. Jeffries (1929) to be liquid iron, by Daly (1930) to be in a "fluid" or "gaseous" state. Its average density is 11.5. It is probable that the inner core of the earth was originally composed of material resembling that found in iron meteorites. Iron meteorites have a specific gravity of 7 or higher. The idea of a liquid inner core is supported by present-day seismology, for the secondary or transverse wave of an earthquake, a kind appearing only in solids, is not transmitted through the inner core.

The methods of palæogeography afford theoretically a splendid insight into the successive geologic stages involved in the upbuilding of the earth. If one could visualize, even in the crudest fashion the changes in geography that have taken place at regular intervals, say 100,000 years, the sequential history of the earth would be in large measure solved. In accordance with the normal sequence of events such a series of pictures should begin with the birth of the earth, from the parent body, the sun. One hundred thousand years later a sufficient change would have taken place in the earth to depict the second scene. A large number of pictures would have to be sketched, 30,000 in fact, if the earth is three billion years old, before the present day is reached, with its magnificent panorama of continents, oceans, irregular coast lines, mountains, plateaus, plains, rivers, lakes, seas, snow fields, glaciers, deserts, and various forms of plant and animal life,

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HERMIT CAMP AT THE END OF THE HERMIT TRAIL, GRAND CAÑON

This tourist camp, 3700 feet below the south rim, is a half mile east of Columbus Point, the imposing central rock tower. This towering spur is composed of horizontal sediments that are green, mauve, red, and gray in color. The camp overlooks the inner gorge of the Colorado River, 700 feet deep

FOOTPRINTS OF A LABYRINTHODONT, COCONINO SANDSTONE, GRAND CAÑON

Footprints made by an amphibian of Permian age as the sands of the Coconino formation were being deposited 210 millions of years ago. The sands were moist when the impressions were made. The weight of the animal compacted them and the footprints were covered and preserved

not to mention the cities and other works of man.

No fault is to be found with the idea, for geologic processes are continuous and they have been so throughout the immensity of geologic time. The difficulty in preparing such a series of pictures arises from the fact that the records of past events, which are preserved in the earth itself, are somewhat fragmentary and, furthermore, they are not dated in terms of years, as man dates his present chronology.

The data most frequently used in estimating the age of the earth are those based on geologic processes such as erosion, sedimentation, and deformation. These processes are in evidence on the surface of the lands. For epochs, other than the present, these data are to be found in the stratigraphic record as preserved in the crust of the earth.

The rate of erosion of the lands is of value as a criterion. Samples of water from representative streams for various climates and topographic reliefs have been taken and analyzed. From more than 8000 analyses F. W. Clarke in his *Data on Geochemistry*, 1924, observes that taking the continents as a whole they are lowered by solvent denudation one foot in 30,000 years. From measurements of the suspended matter collected in the analyzed samples he concludes that the chemical denudation represents but 30 per cent of the total denudation. This gives a mean rate of total denudation at the present time of one foot in 8600 years.

The average height of all lands above sea level has been computed to be approximately 2300 feet. The average depth of the oceans is about 13,000 feet. If the land surface is lowered one foot in 8600 years and the average height of land above the sea is 2300 feet then it would take 19,780,000 years to erode the lands to sea level, assuming that the rate continued uniform to the end, which is not likely. Granting that the oldest rocks on the surface of the earth are approximately 2,000,000,000 years old, that the rate of erosion continued to be one foot in 8500

years throughout all this time, and that the lands were uplifted at the close of each complete erosion period, then the lands would have to have been uplifted 101 times to afford continuous erosion.

The American geologists, Powell, Dutton, and Davis, have shown that the lands have been base-leveled frequently during geologic time. To this level surface Davis applied the term peneplain. Each peneplain was developed as the result of a cycle of erosion. Many ancient peneplains lie buried and preserved as unconformities between different beds of sedimentary rock; others have been elevated and more or less destroyed by later cycles of erosion. These later cycles are uncompleted, since before any one of them could be finished the lands were uplifted and a new cycle inaugurated. In fact no extensive peneplains, not uplifted or dissected, are known to exist at the present time.

Nevertheless, it is apparent to geologists that the earth has been in repose repeatedly, as far as denudation is concerned; at such times shallow seas have spread far and wide over base-leveled lands; new areas of deposition have thus arisen; sedimentation accompanied by slow subsidence in well defined troughs followed; then folding, crumpling and overthrusting of the horizontal strata appeared as the result of lateral compression; this was followed by a general uplift of the folded rocks into high mountains by forces acting from beneath the crust. Such uplifts were frequently accompanied by the intrusion of igneous and volcanic rocks into the distorted mass. With the uplift of the region a new cycle of erosion was inaugurated, the agents of erosion again renewed their efforts to reduce the new landscape to a peneplain. This in brief is the history of various regions of the earth's crust, particularly where numerous old and young mountains exist.

While the rate of denudation in the various cycles of erosion has not been preserved, the sediments that were deposited in the shallow seas lying upon and about the margins of the continents and

FOSSIL ALGÆ IN A ROCK WALL, PHANTOM RANCH MESS HOUSE, BRIGHT ANGEL CAÑON, ARIZONA
The algæ in this isolated block of Bass limestone from the Unkar group, middle Proterozoic, led to the discovery, 1927–1930, by Dr. David White and Mr. Lincoln Ellsworth, of additional specimens of these ancient lime-secreting plants

in the depressed troughs have been preserved, except where erosion removed all or a part of the uplifted beds. Due to the shifting of the areas of deposition for different epochs the entire series of these sedimentary strata, which total some 529,000 feet or 100 miles in thickness, are not all to be found at any one place, but in different places upon the face of the earth.

Where the erosion of the lands by rivers proceeded in cyclical manner, the deposition of the transported land derived sediments in marine basins followed in accordance with cycles of sedimentation. Conglomerates and sandstones were laid down near shore and at the base of the series; shales and limestones were deposited farther out, or on top of the more coarsely bedded sediments as the rivers became longer or less active, with gentler grades and greater sorting powers.

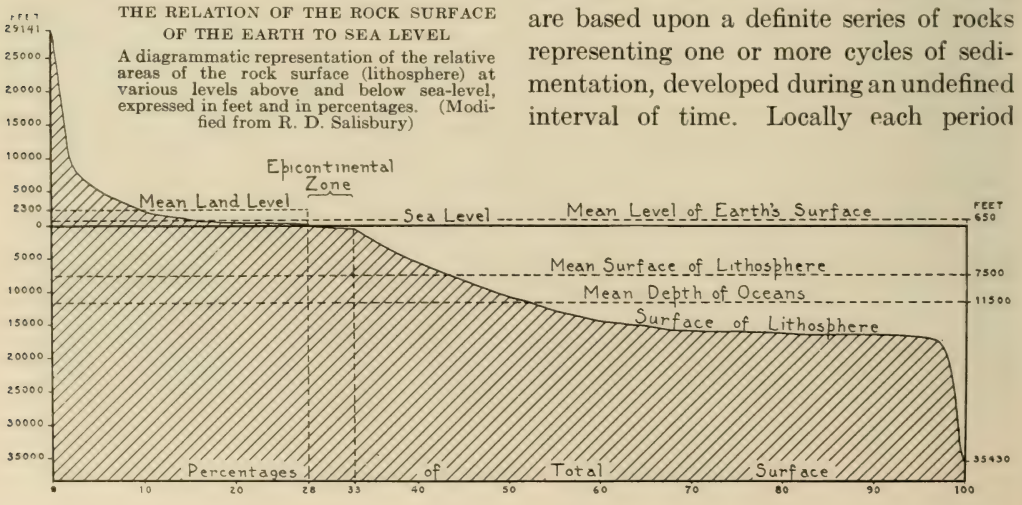
The various forms of animal and plant life which lived in the sea at the time the deposits were laid down were entombed, as they died, by the incoming sediments. Their remains constitute the fossils of the sedimentary rocks. Different species and different forms of life are found in rocks, not only where they were deposited in regular sequence, but in areas where a more recent formation extended over older rocks and a gap in time and in sedimentation was recorded thereby. Fossils are invaluable to the stratigrapher, for where a regular sequence of beds occurs the changes in the species, from bed to bed, permit the establishment of a faunal scale and this may be used elsewhere in deciphering the relations of beds where the sequence may be different or where the character of the rocks may have changed.

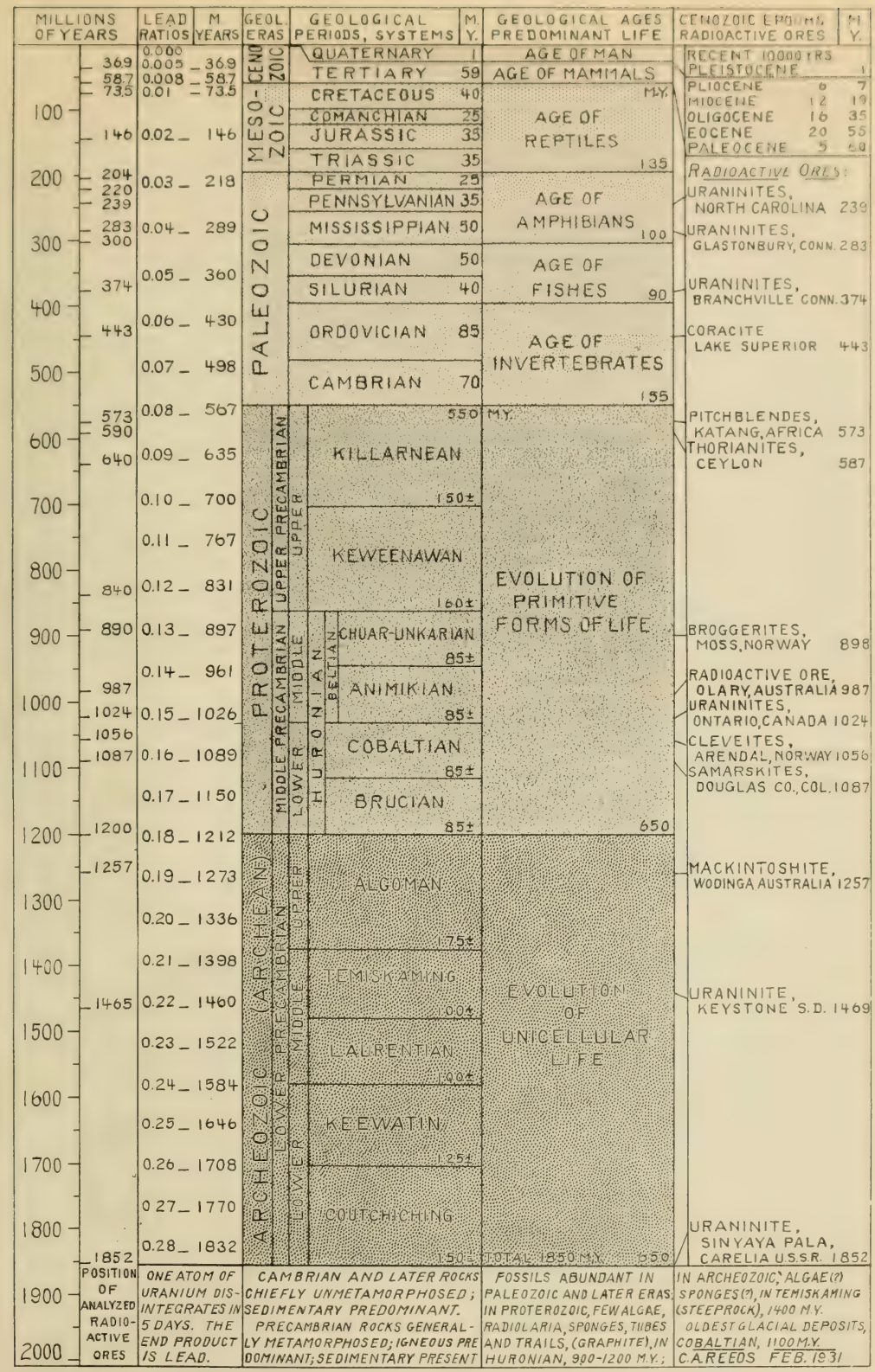
Beginning with William Smith in England in 1796, geologists have built up a geological time scale, the major features of which are applicable to the known rocks of the world. Smith, as a local surveyor, came to recognize beds of rock from place to place by the fossils which they contain. By continued observation over a number of years and much traveling, he was able in 1815 to publish a geological map of England and Wales on which he showed the distribution and succession of rocks of different ages. The local names which he applied to the beds have remained in use to this day.

The geological time scale, as now recognized, is the work of many geologists. It is a kind of chronological chart with various subdivisions, the oldest rocks appearing at the bottom, the youngest at the top. It is the geologists' alphabet. The terms ending in *zoic* refer to eras of life, which constitute major divisions. Each era is divided into periods, which are based upon a definite series of rocks representing one or more cycles of sedimentation, developed during an undefined interval of time. Locally each period

THE RELATION OF THE ROCK SURFACE OF THE EARTH TO SEA LEVEL

A diagrammatic representation of the relative areas of the rock surface (lithosphere) at various levels above and below sea-level, expressed in feet and in percentages. (Modified from R. D. Salisbury)





RADIOACTIVE CHART OF GEOLOGICAL TIME

Note: For every 1,000,000,000,000 uranium atoms (or a mass weighing 1/40,000,000,000 of a gram) one atom explodes every five days. Five eras are shown on this chart; see page 146 for radioactive clock of geological time, showing seven eras.

Ewing Galloway, N. Y.

INNER GORGE OF THE GRAND CAÑON, ARIZONA

View as in frontispiece. Looking down the Colorado River from the Kaibab suspension bridge. Rock section from river bed to top of Isis Temple: *Archeozoic:* V. Vishnu schist; *Proterozoic:* B. Bass limestone; H. Hakatai shale, Sh. Shinumo quartzite; *Palaeozoic:* (Cambrian) T. Tapeats sandstone, BA. Bright Angel shale; (*Mississippian*) R. Redwall limestone, (Permian) Ss. Supai sandstone and shale, C. Coconino sandstone

and system of rocks is further divided into epochs and formations of rocks. These local designations, which are numerous and variable from place to place, have not been included in this general chart.

To illustrate the meaning of portions of this chart the wonderful section of rocks exposed in the Grand Cañon of the Colorado River in Arizona may be cited. Across a plateau, the upper surface of which rises from 7000 to 8000 feet above sea level, the Colorado River has eroded a trench about 217 miles long and a mile deep at the western end. This trench consists of two conspicuous features, one, an outer cañon, which is 4600 feet deep from the north rim and from 8 to 20 miles across, the other, an inner gorge which is another 1000 feet deep, narrow, and V-shaped in cross section. The buttressed walls of the outer cañon are composed of a succession of horizontally stratified sedimentary rocks; limestones, sandstones, and shales representing the Permian, Mississippian, and Cambrian periods of the Palaeozoic era. Below these level strata the river has cut its inner gorge through tilted sedimentary rocks; quartzite, limestone, and shale, some two miles thick, which are of Middle Proterozoic age. Below this series the river has cut its way into a crystalline basement rock, without stratification,which belongs to the earliest era, the Archæozoic. While this great section is wonderfully impressive to those who visit the Cañon, the story has been but partly told.

The ancient basement rocks are separated from the overlying Proterozoic series by a great erosion interval. This interval is represented in the section by an uneven surface known as an unconformity. Prior to occupying their present position, these basement rocks in the bed of the river

which are 3000 feet above sea level, were deeply buried, crushed, smashed, and recrystallized by the processes of diastrophism as they lay at a lower level beneath a thick cover of rock. This cover was removed slowly by surface weathering, wind, and running water, acting throughout a complete cycle of erosion. The present erosion of the Grand Cañon is but a small beginning as compared with the great erosion period under consideration which was completed perhaps 1,200,000,000 years ago.

On top of the gently subsiding peneplain thus established, sediments of the Proterozoic Chuar and Unkar series were slowly deposited. It was a long enduring period, for the deposits are more than 11,000 feet in thickness. The sediments were at least partly of marine origin, for Dr. David White and Mr. Lincoln Ellsworth have collected primitive forms of plants known as fossil algæ, from the Bass limestone, which appears just above the base of the Unkar series. These are the oldest fossils in the Grand Cañon.

Following the long period of deposition, diastrophism renewed its activities. The Proterozoic series was faulted and tilted, in fact, great block mountains thousands of feet in height were uplifted.

This epoch of mountain uplift was followed by a second long period of erosion, during which time the region was again worn to a smooth plain, except for a few low lying hills. In many places the thick Proterozoic series was entirely removed and the basement rocks again exposed except where a few downfaulted blocks of the Proterozoic rocks were preserved. These downfaulted blocks of sediments are all that remain of the great Proterozoic era in

SILICIFIED FORMS OF FOSSIL ALGÆ IN THE BASS LIMESTONE

Collected by Mr. Lincoln Ellsworth from the middle Proterozoic rocks, near the mouth of Bright Angel Cañon, Arizona. This specimen is of exceptional interest to students of the early remains of life. The Radioactive Chart of Geological Time indicates that it is about 940 million years old

this region. A second great line of unconformity separates the Proterozoic rocks from those of Palæozoic age.

As the land again sank, the seas of Cambrian time rolled in over the smoothed plain to inaugurate another great era of deposition in this region, the Palæozoic. Horizontally disposed sandstones, shales, and limestones were deposited. Amongst them may be found the fossil shells of various invertebrates, the tracks and remains of trilobites, et cetera. In the wonderfully impressive Palæozoic series of beds, the Orodovician, Silurian, and Devonian periods are missing. They are represented by an unconformity. We shall know more about what happened to them when the Grand Cañon is more fully explored.

As one views the Grand Cañon from the rim at El Tovar, it is difficult to realize that the rim rock, the Kaibab limestone, of Permian age, is not the top of the series of sediments. The great cliffs on the north and east that overlook the region are the higher strata that once extended over the whole district of the Grand Cañon. The distant strata represent deposits of Permian, Mesozoic, and Tertiary age. They are about a mile in thickness. Two major cycles of erosion are preserved in these rocks, one at the end of the Permian, the other at the close of the Mesozoic era. Each denotes prolonged erosion and a great interval of time. This Grand Cañon section, although extremely interesting and impressive, represents but portions of the geological time scale.

We have now suggested briefly the part played by the great geologic processes during the upbuilding of the earth. The question arises how long have these forces been acting? While various criteria have been used in the investigation of this problem, the data most frequently consulted are the sodium salts of the oceans, the thickness of the sedimentary rocks, and the radioactivity of the igneous rocks.

The sodium in the oceans has been derived from the land by the weathering of igneous rocks. It has been transported

GLACIAL BOWLDER OF VARVED CLAY OF MIDDLE PROTEROZOIC AGE

The seasonal layers of this compact rock were deposited in a glacial lake of Cobaltian time, 1100 million years ago, in Ontario Province, Canada. This specimen of the oldest known glacial period was carried by the ice of the last Pleistocene glaciation to Battle Creek, Michigan. E. M. Brigham collector

from the land to the sea by rivers carrying it in solution. As noted by J. Joly of Dublin in 1899, the mass of the ocean waters is 1,180,000 million million tons. The percentage of sodium in the oceans was calculated by him to be 1.08 per cent by weight, so that there are 12,600 million million tons of sodium in the oceans. The amount of sodium contributed by the rivers to the sea annually has been variously estimated. After applying certain corrections, A. Holmes, 1927, calculated that the yearly increment amounts to 35 million tons. The amount of sodium in the sea divided by this annual rate gives 360,000,000 years as the age of the oceans.

VARVED CLAY OF LATE PLEISTOCENE AGE
HAVERSTRAW, N. Y.

This partial section of Haverstraw brick clay, 30,000 years old, was deposited seasonally in fresh water as the ice of the last glaciation retreated northward. The space between pins represents a year. The lighter colored layers of fine sand are the summer deposits; the dark bands of clay are the winter layers

This calculation is based upon the present rate of denudation and delivery. It is most probable that the rate is much higher now than during many of the former geologic ages when the lands were less high, less extensive, and the seas more widespread. To account for these differences, J. W. Gregory (1921) recommends that the present estimates based upon sodium should be multiplied by five giving a total of 1,800,000,000 years as the age of the oceans.

The age of the earth based upon the thickness of the stratified formations is more difficult to apply since the average annual rate of deposition of sediments is not definitely known for the present or for past epochs of geologic time. A. Holmes, 1927, estimates the thickness of the sedimentary deposits of various ages as 529,000 feet or 100 miles. J. H. Bretz, 1926, on the basis of several estimates obtains an average rate of accumulation of one foot in 880 years. These figures give a total of 465,520,000 years as the amount of time required for the deposition of the sedimentary record.

This estimate does not include, however, the beds which were deposited in epicontinental seas, uplifted and subsequently removed by erosion, leaving only an erosion plane as a record of the events. Neither does it take into consideration those great gaps separating the five eras of geologic time when sedimentation was presumably confined to the margins of the continental platforms. Ocean waters now cover the margins of the continental platforms to a depth of 600 feet and embrace continental areas totaling 10,000,000 square miles. J. Barrell, 1917, notes that geologic processes, embracing erosion, sedimentation, and deformation recur in composite rhythms in which landscapes alternate with seascapes and geosynclinal areas of sedimentation with high mountains. The processes of sedimentation are complex and variable, defying rates of deposition. Areas of sedimentation alternate with scour and fill, the resulting product represents merely the balance between these two processes. In some areas sediments may not always have reached so far, in others they may have been carried

away to more distant spots, leaving small or large gaps in the horizontally disposed sediments known as disconformities. On the basis of these numerous deficiencies in the stratigraphic record it would seem that the above estimate of 465,520,000 years should be multiplied by a small figure such as 4, to account for the total time involved since sedimentation began, namely, 1,862,080,000 years ago.

Another line of evidence, which has yielded remarkable results as to the age of the earth is the radio-active method. It was first used in this connection by Boltwood of Yale in 1907. It is based upon the invariable rate of disintegration of the radioactive substances, such as uranium, thorium, radium and actinium, which possess high atomic weights and disintegrate with the continuous emanation of helium into substances of lower and lower atomic weights, terminating in lead. While chemists and physicists have analyzed but a comparatively small number of rocks of different ages containing radioactive minerals, the determinations so far made yield results which are in accord with the sequence of rocks as determined by geologists. The radioactive method affords age determinations which are more accurate than that produced by any other known method.

According to G. von Hevesy in *Science*, Nov. 21, 1930, single atoms of uranium and other radioactive substances explode. The number of particles exploding and decaying in unit time is strictly proportional to the number present. Thus where one atom of uranium out of 1,000,000,000,000 atoms, (or a mass weighing 1/40,000,000,000 of a gram) explodes and disintegrates every 5 days, 73.05 atoms disintegrate in like manner in the course of a year. If the mass and the number of atoms be 10 times as large, 10 atoms will decompose in five days. If the mass be 100 or 1000 times as large, 100 or 1000 atoms will decompose in the same time. Hence, whether the mass be 10, 100, or 1000 times larger, it disintegrates at the same rate.

Uranium disintegration is thus a strictly uniform process whose velocity has remained unchanged throughout geological time. Von Hevesy says that it is the nucleus which is involved in the decay, and nuclear processes proceed independently of temperature, pressure, and other external conditions. Hence, he asserts there is absolutely no reason to believe that the process has gone forward at any different rate than at present at any period in the earth's history.

To students of this subject it is a well-known fact that the disruption of a uranium atom is always accompanied by the radiation of an alpha-particle, which is a charged helium atom, or by the loss of a beta-particle, which is a free electron. The alpha-particles leave the atom with a velocity of 8800 miles per second and travel a distance of about 2.8 cm. in air and about 0.013 mm. in mica before they become powerless. The beautifully colored "pleochroic halos" seen in mica (biotite) under polarized light are produced by these alpha particles as they are emitted by the contained uranium and the decomposed products of uranium. The fact that the halos, corresponding to the various radioactive substances, have the same diameter, indicates that the rate of decay has remained the same throughout the ages. To apply the rate of uranium decay as a measure of time it is necessary as von Hevesy says to obtain (1) the total quantity of uranium that has decayed in some mineral since the solidification of the earth, and (2) the rate of that decay.

Accompanying the radiation of alpha-particles from uranium it is known that one atom of helium, an inert gas, rises from the decay of each atom of uranium. Although a small portion of this helium escapes, most of it collects in the uranium bearing rock, where its volume gives a

Photograph by Barnum Brown

STRATIFIED CRETACEOUS DINOSAUR BEDS, ALBERTA PROVINCE, CANADA

The man near the center of the picture stands on the contact between the marine Pierre beds below and the fresh-water Belly River dinosaur beds above. The contact denotes not only a change in the character of the sediments, but a lost interval of time occurring about 65 million years ago

measure of the age of the rock. Lord Rayleigh noted that one cubic centimeter of helium may be produced from one gram of uranium in 9,000,000 years. Since a small portion of the helium gradually escapes, this method gives but a minimum age. On this basis, age determinations of ancient rocks have been made to the amount of 570,000,000 years.

Uranium has an atomic weight of 238, helium 4. Hence, as the decay proceeds and helium is liberated, the products of the decay have atomic weights, 234, 230, 226, 222, 218, 214, 210 and 206. The atomic weight of a beta-particle is 1/1800, hence, when it is lost, the atomic weight is decreased by an insignificant amount.

The atomic weight 206, which is lead derived from uranium, is of special interest in radioactive determinations, since it is a solid product and does not disintegrate. It may be observed that 238 parts of uranium produce 206 parts of lead as 32 parts of helium are developed. Hence, from the known rate of the production of helium from uranium, A. Holmes, 1927, calculates that a million grams of uranium give rise to 1/7400 of a gram of lead every year. Holmes also presents formulæ for making age determinations from the various radioactive minerals. Thus after determinating the lead content of the uranium minerals it is possible to calculate what proportion of the uranium has decomposed since the mineral was formed.

In the *American Journal of Science* for March, 1927, A. Holmes and R. W. Lawson reviewed the methods of determining the radioactive disintegration of 18 samples and presented 22 determinations, the results of which have been incorporated in the left margin of the geological time scale on page 137. In the same journal, Aug., 1930, A. F. Kovarik described two additional analyses of ancient rocks, one for 1,465,000,000 years, the other for 1,852, 000,000 years. These have also been added to the chart.

The radioactive method, which is based upon the natural disintegration of uranium to lead, is of great importance for it enables us to determine the following interesting things about the earth:

1. The age of the oldest igneous rocks containing radioactive minerals, that is, the minimum age of the earth.
2. The date of various events in the later history of the earth.
3. The nature perhaps of various transformations in the gaseous and liquid stages of the earth's history.
4. The maximum age of the earth.

As to these various points it may be said that the oldest radioactive mineral so far determined is a specimen of Uraninite from Sinya Pala, Carelia, in northwestern U.S.S.R., and that its age is 1,852,000,000 years as determined by A. F. Kovarik, Sloane Laboratory, Yale University, August, 1930. Another specimen of the same mineral from Keystone, South Dakota, as determined by Prof. Kovarik, gave 1,465,000,000 years. It is probable that other specimens yielding an even greater age may be found and that the minimum age of the earth, that is, the formation of the crust, may be considered to have begun approximately 2,000,000,000 years ago.

The age determinations of various events in the later history of the earth have been entered in the geological time scale on page 137.

The third and fourth points are of special interest, since the early history of the earth is still obscure. According to von Hevesy, 1930, the uranium-lead method is not only of value in determining the lower limit of the age of the earth's materials, but of the chemical elements. As a chemist he considers that the transformation of uranium into lead had already progressed to a certain point while the earth's material was still gaseous. He asserts that this lead with atomic weight 206 did not remain isolated, but mixed with lead (208) formed by the decay of thorium and as a result common lead (207) was produced. He goes on to say that approximately half of our common lead was formed from uranium before the earth's materials had solidified. He cites F. W. Aston as having proved recently that ordinary lead is a mixture of uranium-lead and thorium lead. He considers that lead formed in uranium minerals has had no opportunity to mix with thorium lead and consequently it has remained fixed as uranium-lead. Thus the ratio of all the uranium to about half the common lead (plus the uranium-lead) present in the whole earth must give the age of the earth's material. His considerations give about 3000 million years as the upper limit of the age of the minerals; it is also the lower limit of the age of the earth's material. He draws a distinction between the few radioactive elements, which have altered according to accurately known laws during this long time, and the other elements which built up the earth's constituents and have undergone no change.

SECTION OF FORDHAM GNEISS, ARCHÆOZOIC AGE
NEW YORK, N. Y.

The folded and contorted bands of light and dark colored minerals represent lines of segregation of the mineral matter, and folding when in a plastic state. It is typical of many Archæozoic rocks. Specimen from excavation, eastern abutment of Fort Washington bridge over Harlem River. Age problematical, perhaps 1800 million years

MUD FILLINGS OF "SUN CRACKS," SUPAI FORMATION

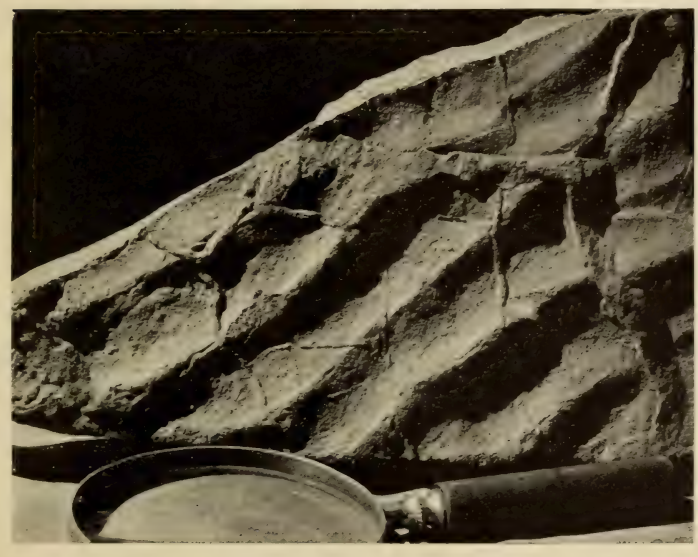
A specimen of lower Permian age that is some 215 million years old. It exhibits the same physical phenomenon as is found in the Hakatai shale specimen 935 million years old of middle Proterozoic age. From the Grand Cañon of Arizona. Lincoln Ellsworth Collection, 1930

The foregoing determinations have had to do with the crust of the earth. Since the earth's interior is inaccessible, the geochemist turns to the meteorites and assumes that the iron meteorites correspond to the core of the earth, and the stony meteorites to the more or less silicate-like material lying between the core and the crust.

F. Paneth of Berlin developed in 1926 the methods for determining the helium content of meteorites. He notes that the iron meteorites when heated to a red heat loose no trace of helium. According to von Hevesy, 1930, Paneth has found for the iron meteorites a maximum age of 2600 million years.

These data are significant. It lends support to the theory that the original materials of the earth and of meteorites may have come from a common celestial source. It also implies that the youthful earth, which grew presumably from the inner core outward by the addition of layers of planetoid and planetesimal matter, began its development 2,600,000,000 years ago. The oldest surface rock so far analyzed yields an age of 1,852,000,000 years. The difference in age between the oldest rock and the oldest meteorite is 748,000,000 years. May not this difference, or some 600,000,000 years, represent the time consumed in the upbuilding of the primeval earth?

In conclusion it may be stated that these radioactive determinations are not only astounding, but remarkable. Al-

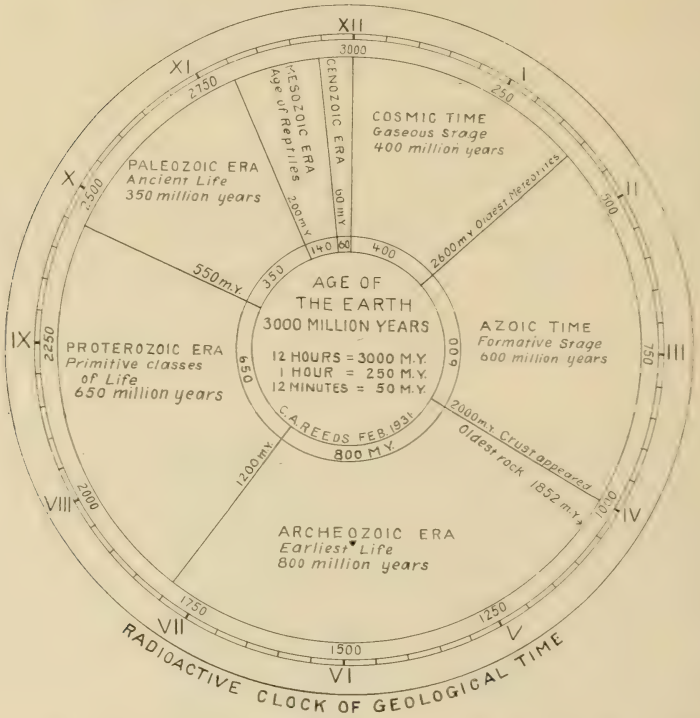


PROTEROZOIC RIPPLE MARKS AND "SUN CRACK" IMPRESSIONS

This slab of red Hakatai shale of middle Proterozoic age is some 935 million years old. It shows that the same physical phenomena were in force during the early eras of the earth's history as are in evidence today. Specimen from the Grand Cañon of Arizona. Lincoln Ellsworth Collection, 1931

though the method is still young the results are dependable. The method is based upon the natural rate of disintegration of the atoms of the few radioactive elements. This rate cannot be changed by any known human or physical agency. It is thus a reliable and thoroughly scientific method. When its application has been extended to numerous samples of radioactive rocks and minerals from all parts of the world, embracing rocks of all ages, then we shall know, in all probability, how old the earth is.

Upon the basis of knowledge for 1931, we may consider the crust of the earth to be 1,852,000,000 or about 2,000,000,000 years old; the inner core, 2,600,000,000 years old; and the upper limit of the minerals, or materials of the earth, as 3,000,000,000 years old, as noted below in the radioactive clock of geological time. The radioactive determinations and the oldest fossils indicate that primitive life was present on the earth one and one-half billion years ago; stone implements and human remains in Pliocene deposits imply that the human race was on the earth about one and one-half million years ago.



This clock face of 12 hours shows how 3000 million years may be allotted to seven stages in the geological history of the earth. The first and second stages representing the gaseous and formative eras respectively, are not shown on the preceding more detailed radioactive chart of geological time, page 137.

Reference

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